The Children of Aphrodite

The Proliferation and Threat of Unmanned Aerial Vehicles in the Twenty-First Century

A Monograph

by

MAJ Darin L. Gaub

United States Army

School of Advanced Military Studies

United States Army Command and General Staff College

Fort Leavenworth, Kansas

AY 2011

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
13-05-2011	Master's Thesis	JUN 2010 – MAY 2011

4. TITLE AND SUBTITLE
The Children of Aphrodite
The Proliferation and Threat of Unmanned Aerial Systems In the Twenty-First Century

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
MAJ Darin L. Gaub

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Command and General Staff College
ATTN: ATZL-SWD-GD
Fort Leavenworth, KS 66027-2301

8. PERFORMING ORG REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution is Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Unmanned Aerial Vehicles (UAVs) provide crucial intelligence collection, and lethal targeting capabilities for United States, and other armed forces around the world. In Iraq and Afghanistan, they continue to demonstrate their value to commanders of all services. The United States will even use UAVs as a first line of defense in nations that prefer to keep a lower-profile while supporting U.S. actions within their borders. This is the case in Pakistan, Yemen, and potentially others as well. However, just as nations realized the value of airpower in World War I, many other nations and organizations also see the value in employing UAVs of all sizes. Where the United States employs UAVs as means to perform precision attacks to limit casualties, some non-state actors might use UAVs to spread fear, and possibly chemical or biological attacks. Others see UAVs as a means to conduct covert long-range reconnaissance of targets, transport illicit cargo with limited exposure, or to cause a desired reaction. State actors such as China, Israel, and Iran continue to develop UAVs with multiple capabilities, including air-to-air combat, long-range attacks, and reconnaissance. The U.S. military must improve its limited Counter-UAV doctrine and training programs to address this threat.

15. SUBJECT TERMS
Unmanned Aerial Systems, Unmanned Aerial Vehicles, Counter-UAV, Counter-UAS, Homeland Security, UAS Threats, Foreign UAS Threat, UAV, UAS, UCAV, Airspace, Air Defense, Air Defense Artillery, Radar

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. PHONE NUMBER *(include area code)*
(U)	(U)	(U)	(U)	44	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

SCHOOL OF ADVANCED MILITARY STUDIES

MONOGRAPH APPROVAL

Major Darin Lee Gaub

Title of Monograph: The Children of Aphrodite

Approved by:

_____ Monograph Director
Bruce E. Stanley

_____ Monograph Reader
Michael D. Stewart, Ph. D.

_____ Director,
Wayne W. Grigsby, COL, IN School of Advanced Military Studies

_____ Director,
Robert F. Baumann, Ph.D. Graduate Degree Programs

Abstract

The Children of Aphrodite: The Proliferation and Threat of Unmanned Aerial Vehicles in the Twenty-First Century, by Major Darin L. Gaub, 45 Pages.

Unmanned Aerial Vehicles (UAVs) provide crucial intelligence collection, and lethal targeting capabilities for United States, and other armed forces around the world. In Iraq and Afghanistan, they continue to demonstrate their value to commanders of all services. The United States will even use UAVs as a first line of defense in nations that prefer to keep a lower-profile while supporting U.S. actions within their borders. This is the case in Pakistan, Yemen, and potentially others as well. However, just as nations realized the value of airpower in World War I, many other nations and organizations also see the value in employing UAVs of all sizes. Where the United States employs UAVs as means to perform precision attacks to limit casualties, some non-state actors might use UAVs to spread fear, and possibly chemical or biological attacks. Others see UAVs as a means to conduct covert long-range reconnaissance of targets, transport illicit cargo with limited exposure, or to cause a desired reaction. State actors such as China, Israel, and Iran continue to develop UAVs with multiple capabilities, including air-to-air combat, long-range attacks, and reconnaissance. The U.S. military must improve its limited Counter-UAV doctrine and training programs to address this threat.

Acknowledgements

This project would not have been possible without the assistance of the Staff at the Combined Arms Research Library, Fort Leavenworth, Kansas. Specifically, John and Elizabeth Duibisson conducted research, and obtained necessary research materials.

I would like to thank my monograph syndicate for all the proofreading assistance, and especially Bruce Stanley for his guidance as my monograph director. He always knew where I needed to go in order to complete this paper, yet let me pursue multiple lines of inquiry during the process of discovery. I would also like to thank the following who contributed interviews, emailed information, proofread, or otherwise contributed to this project:

SES Dyke Weatherington, OSD, Deputy Director of Unmanned Warfare, Acquisition, Technology, and Logistics (Interview)

Brigadier General (Promotable) Anthony Crutchfield, USA, Commanding General U.S. Army Aviation Center of Excellence (USAACE) (Senior Mentorship)

Brigadier General (Retired) Mitch Mitchener, President, CounterUAV Inc. and Former Director of the U.S. Army's Safety Center (Reading)

Dr. Dennis Gormley of the Monterrey Institute's James Madison Center for Non-Proliferation Studies (Interview)

Dr. Brian Jackson, Senior Physical Scientist for the Research and Development (RAND) Corporation (Interview)

Dr. Robin Higham, Kansas State University, Department of History (Emails and Reading)

Colonel (Retired) Gregory Kern, USAF, Deputy Director of ISR, OSD-I (Interview)

Colonel (Retired) Donald Hazelwood, U.S Army, former Product Manager UAS, General Manager-UAS Logistics, Support Science and Engineering Services, Inc. (Interview)

Colonel Keith Hirschman, USA, Product Manager UAS (Interview)

Commander Basilio Bena, USN, Joint UAS Center of Excellence (Email Interview)

Colonel Adam Hinsdale, USA, Deputy Director of ISR Programs, OSD-I (Interview)

Mr. Scott Mandeville, Chief Executive Officer (CEO), CounterUAV Inc. (Emails)

This study would not have been possible without their insights, and in some cases continued professional development.

I would like to thank my parents who instilled a love of God and Country in me that will never depart. You have always supported my desire to serve this country in any capacity.

I must thank my beautiful bride Sonda, my daughter Dennara, and my son Declan for all the sacrifices they have endured through the years of deployment, training, and tasks that seemed to constantly draw me away. Your devotion and love for me is bedrock for me to rest on even in the most difficult of times.

Finally, I thank my Lord and Savior Jesus Christ. Nothing on this earth is worth accomplishing without your grace. II Kings 6:17.

Table of Contents

Acronyms

AC2	Airspace Command and Control
ADAM	Air Defense Airspace Management
BAE	Brigade Aviation Element
BCT	Brigade Combat Teams
C4ISR	Command, Control, Communication, Computer, Intelligence, Surveillance, and Reconnaissance
CAB	Combat Aviation Brigades
Counter-UAV	Counter Unmanned Aerial Vehicle
CTC	Combat Training Center
DOD	Department of Defense
DOTMLPF	Doctrine, Organization, Training, Material, Leadership, Personnel, and Facilities
ER/MP	Extended Range/Multi-Purpose **(Now known as the Gray Eagle)**
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
JP	Joint Publication
NTC	National Training Center
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OSD	Office of the Secretary of Defense
PEO AVN	Program Executive Office Aviation
PM	Product Manager
ROE	Rules of Engagement
SECDEF	Secretary of Defense
SUAS	Small Unmanned Aircraft System
SUAV	Small Unit Unmanned Aerial Vehicle
TF	Task Force

TUAS	Tactical Unmanned Aircraft System
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Aerial Vehicle
U.S.	United States
USA	United States Army
USAF	United States Air Force
USJFCOM	United States Joint Forces Command
USN	United States Navy

Introduction

I think this war is going to give you the revolution in military affairs.
-- Eliot Cohen[1]

During an interview with the Washington Post, shortly after the attacks on the United States of September 11, 2001, military strategist Eliot Cohen argued that the use of Unmanned Aerial Vehicles (UAVs) in Afghanistan and Yemen foretold a likely Revolution in Military Affairs (RMA). The fact that United States Air Force (USAF) Predator UAVs patrolled the skies over Yemen and Afghanistan in 2001, and actively flew reconnaissance missions, supported his assertion. In fact, the following year a CIA controlled drone fired one of the first UAV launched missiles in America's "Global War on Terror," when it engaged and destroyed a vehicle carrying the mastermind of the bombing of the U.S.S. Cole in 2000, one of America's most wanted terrorists.

Today commanders continue to rely on the capabilities that UAVs bring to the battlefield. Historically, UAVs were the hand maidens of modern industrialized nations with the economy to support the research and development inherent to the development of UAVs. In this environment, the United States leads all countries in the design and fielding of UAVs from the tactical small UAV, to theater and global strike and intelligence, surveillance, and reconnaissance assets organic to primarily the U.S. Air Force, and U.S. Army. However, similar to the advent and growth of airpower during World War I, the UAV is proliferating with multiple nations and organizations considering its employment. In the U.S., UAVs are used for everything from normal peacetime military applications, to border enforcement, forest-fire tracking, police support, search and rescue operations, and various commercial applications. Other nations and organizations use UAVs in similar missions, but also in ways unique to their needs.

The success of UAVs on the modern battlefield, as well as technological improvements that ensure UAV technologies are cheaper and easier to access ensures that UAVs will enjoy

[1]Thomas E. Ricks, "U.S. Arms Unmanned Aircraft," Washington Post online, October 18, 2001. http://www.washingtonpost.com/ac2/wp-dyn/A12129-2001Oct17?language=printer (accessed August 16, 2010).

continued use by both American adversaries and allies. In the 2006 Israeli-Hezbollah war, the world witnessed a small "terrorist" force use UAVs as part of a larger strategy to wage a large-scale air war against Israel.[2] In addition, United States forces in Iraq recently shot down an Iranian UAV as it patrolled along the Iranian border with Iraq.[3] The Iranian UAV was suspected of conducting reconnaissance in order to locate weapons smuggling routes into Iraq. More recent video shows an Iranian UAV providing video footage of American aircraft carriers as they transited the Straits of Hormuz.[4] Recent reports also indicate that Syria employed Israeli supplied Heron UAVs in support of operations against the Syrian Kurdish population.[5] Many countries are developing UAV technologies, and many more are purchasing UAV technologies, or both. Export controls on UAV technology are either weak or non-existent, supporting the rapid diffusion of UAV technology across the globe.

Major General James O. Barclay III, former Commanding General of the United States Army Aviation Center of Excellence, recently stated that, "We can send a UAS to look down alleys, around buildings, in backyards, or on a roof to see what's up there, dramatically increasing Soldier protection and preserving the force-a vital force multiplier in this era of persistent conflict." This monograph demonstrates that an adversary can also exploit the same capabilities to counter U.S. forces, and therefore, the proliferation of UAVs around the globe will continue, as will their growing threat to deployed U.S. forces. Therefore, the thesis of this paper is that the proliferation of UAVs increases the tactical and operational risk to deployed U.S. forces. The tested hypothesis states that the proliferation of UAVs has increased said risk, and the research

[2]Anthony H. Cordesman, "Preliminary 'Lessons' of the Israeli-Hezbollah War." *Center for Strategic and International Studies* (August 17, 2006). http://csis.org/files/media/csis/pubs/060817_isr_hez_lessons.pdf (accessed August 10, 2010).

[3]"Iranian Aircraft Down In Flames Over Iraq." Strategy Page online, March 19, 2009, http://www.strategypage.com/htmw/htairfo/articles/20090319.aspx (accessed August 10, 2010).

[4]"Iranian UAVs Monitoring US Navy in Persian Gulf." January 13, 2008. http://www.liveleak.com/view?i=c2e_12002 15726 (accessed August 10, 2010).

[5] Bashar Assad, "Syria massacres Kurds aided by Turkey's Israel-made drones." Debkafile. July 17, 2010. http://www.debka.com/article/8916/ (accessed July 18, 2010).

question associated asks if the proliferation of UAV poses an increased tactical and operational risk to deployed U.S. forces.

This study contributes to the growing literature on UAVs by comparing UAVs to World War I aviation innovations and growth. Predictions of future conceptual developments in UAVs and the threat they pose to deployed U.S. or other friendly forces are more understandable when compared to similar historical circumstances. Acknowledging and understanding the growing threat of UAVs should lead deploying U.S. forces to plan, prepare, and execute courses of action that mitigate the use of UAVs by our adversaries. It should also lead to commanders and staffs at all levels incorporating allied UAVs into planning. The final section of the paper assists deploying forces, and their supporting Department of Defense agencies, by providing a means to think about, and prepare for the use of UAVs by foreign governments, and non-state actors. In order to accomplish this task, the research applies the Joint Forces analytical model of Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) in order to ensure the analysis and recommendations fit within existing joint doctrine.

Assumptions made during the research for this paper include acknowledging that the technological capabilities of foreign UAVs equal what their manufacturers, or government officials claim. In addition, despite the fact that Hezbollah acts in manners consistent with some state actors, it remains a non-state actor. Finally, some consider Israel an adversarial nation, and others consider it a non-adversarial nation. For the purpose of the research, Israel is non-adversarial, despite the fact that whether Israel is adversarial or non-adversarial is ultimately irrelevant to the conclusions of the research.

The research uses following definitions.

Unmanned Aerial System (UAS) - That system whose components include the necessary equipment, network, and personnel to control an unmanned aircraft[6]

Unmanned Aerial Vehicle (UAV) - A powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic or semi-ballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles.[7]

Unmanned Aircraft (UA) - An aircraft or balloon that does not carry a human operator and is capable of flight under remote control or autonomous programming[8]

This paper uses the term UAV (Unmanned Aerial Vehicle) synonymously with UAS (Unmanned Aerial System) in order to prevent confusion. The author acknowledges that the U.S. Army adopts the term UAS rather than UAV in order to encompass all supporting systems beyond just the Unmanned Aircraft (UA).[9]

The research is limited by classification and therefore uses only open source information. The research is delimited to the period A.D. 1910 - A.D. 2011. It is also limited to the definition of Unmanned Aerial Vehicles, and does not include ballistic missiles, balloons, blimps, or target drones.

The research is organized as follows. First, there is a literature review encompassing UAV threats, World War I aviation growth and proliferation, and a review of state and non-state actors. Second, is the paper's research methodology including selection of significant cases, instrumentation, data collection, and data analysis. Third, is the analysis section comparing World War I aviation growth and proliferation to UAV growth and proliferation. Fourth, is a narrative describing conceptual applications for UAVs, and showing how state and non-state

[6]Headquarters, Joint Forces Command. Joint Publication (JP) 1-02, 2009b. *Department of Defense dictionary of military and associated terms.* Suffolk: Doctrine and Education Group, 419.

[7]Ibid.

[8]Ibid.

[9]See Appendix 1 for UAV Classifications.

actors demonstrate growing UAV threats whether directly, or through proliferation activities. Fifth, is a DOTMLPF analysis of the United States military's readiness to address the threat. Finally, is a summary of the main points of the argument, and key conclusions.

Literature Review

This section presents the rationale and structure for researching how UAVs may grow, proliferate, and threaten deployed U.S. or allied forces. It seeks to highlight the prevailing literature discussing trends in UAV use and proliferation, as well as those key trends noted by historians researching the advent of airpower during World War I. The following literature begins with a review of how and why terrorist organizations might use UAVs. The purpose of the review of UAV use by terrorists is to provide context to why UAVs are attractive to many. Dr. Gormley provides the majority of the literature concerning UAV threats in this context. The purpose for the review of World War I aviation history is to compare the advent of airpower to the turbulent beginnings of UAVs. Dr. Higham provides the most relevant historical perspective on the beginnings of airpower during World War I. It concludes with a review of trends in military transformation and UAV use by China as a state actor, and Hezbollah as a non-state actor supported by a state actor.

UAV Threats

Gormley argues that UAVs pose a threat that could affect both U.S. interests abroad and inside U.S borders.[10] UAVs previously served primarily as reconnaissance aircraft, but then increasingly became a means for precise weapons delivery, thus more attractive to terrorist organizations. In addition, access to dual-use technologies provides terrorists with relatively easy off-the-shelf means for building UAVs, especially when assisted by a state power.[11] As well,

[10]Dennis M. Gormley, "Addressing the Spread of Cruise Missiles and Unmanned Aerial Vehicles (UAVs)," Center for Nonproliferation Studies (CNS), Washington, D.C., March 2004. http://www.nti.org/e_research/e3_39a.html (accessed 10 August 2010).

[11]Dennis M. Gormley, "UAVs and Cruise Missiles as Possible Terrorist Weapons," in James Clay Moltz, ed., New Challenges in Missile Proliferation, Missile Defense, and Space Security, Occasional Paper No. 12. Monterey, CA: Monterey Institute's Center for Nonproliferation Studies, 2003, 1-4.

terror groups have the means and desire to build UAVs, which can be effectively employed and remain difficult to counter using today's technology.[12] Additionally, the U.S. is unable to deal with the challenge of terrorist access to UAV technologies alone. However, it can exert leadership in order to achieve a level of consensus with existing non-proliferation partners.

Similarly, Miasinkov argues that UAVs may prove useful in a wide variety of military missions. Countries remain concerned about UAV proliferation due to their low costs and easy access to UAV technology. Terrorists desire access to UAVs because they allow for the targeting of difficult to reach areas, wide area attacks, and launch site flexibility. Limited defenses against UAVs and the existing potential for accidental targeting of innocent airliners remain a concern for potentially targeted nations, and a reason for terrorist organizations to continue to pursue UAVs. He concludes by stating that the use of UAVs by terrorist organizations is technically possible, that the distribution of weapons of mass destruction by a UAV poses the greatest threat, and governments need to address how civil uses for UAVs would likely increase proliferation.[13]

In research addressing the continuing growth and proliferation of UAV technologies, P.W. Singer states that there is no guarantee of victory for the U.S. in a technology-based war. One reason why the U.S. could lose this type of war is the rapid proliferation of technology around the world; a timeline now measured in months rather than years. Over 40 countries are now building, buying, or employing UAVs, with two-thirds of the world's spending on UAVs in 2010 coming from countries other than the United States. He concludes that the world must prepare for terrorist use of UAVs to deliver "deadly payloads." Also, the U.S. needs a strategy to deal with an attack against the U.S. homeland using UAVs.[14]

---

[12]Dennis M. Gormley, "Globalization and WMD Proliferation Networks: The Case of Unmanned Aerial Vehicles as Terrorist Weapons," Strategic Insights V, no. 6 (July 2006) : 5.

[13]Eugene Miasinkov, "Threat of Terrorism Using Unmanned Aerial Vehicles: Technical Aspects," Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, Dolgoprudny, June 2004. http://207.5.18.146/UAV/UAV-report.pdf (accessed August 11, 2010).

[14]P.W. Singer, Wired for War: The Robotics Revolution and Conflict in the Twenty-first Century. (New York: The Penguin Press, 2009), 238-250.

- The number of countries with UAVs ranges from 40-150, demonstrating how difficult it is to track where UAVs may be employed next.

The proliferation of UAV technologies should not come as a surprise because they provide some of the same capabilities as manned airplanes for a fraction of the cost.[15] In addition, long standoff, the ability to reach over borders, and the capability of employing unconventional weapons attracts terrorists to UAVs.[16] Jackson argues that the increasing capabilities of existing UAVs move well beyond the previous "hobbyist-driven" market. He states that threat models must include technology transfers to terrorist organizations, studying the foreign UAV threat, foreign UAV acquisitions, and increased diplomatic efforts to strengthen existing arms control agreements.[17] Literature covering how terrorists might use UAVs remains important to this research as it describes motivations and capabilities of terrorist groups as well as capabilities of UAVs that are attractive to terrorists. The same reasons given to explain why terrorists might use UAVs provides background into why nation-states or state-sponsored organizations might want to attack deployed U.S. forces with UAVs.

Advent of Airpower

Since the mid-nineteenth century, technology has underpinned the progress of civilization, and at the heart of this progress, aviation epitomizes the idea of high-technology pursuits and the air power revolution. Higham provides a narrative on the advent of aviation during World War I that is similar to the current growth of UAVs in the military and civil market. He states that the period of 1908-1927 rapidly transformed aviation due to the outbreak of war. The slow development of more powerful engines initially hampered the growth of airpower, yet the outbreak of war between Italy and Libya in 1911 demonstrated the value of airplanes to commanders. Although the military still did not know what to do with airplanes when World War I broke out, continued increases in lifting capacities, due to more powerful and capable engines, provided opportunity for rapid change. Missions started with reconnaissance, then grew

[15]Brian A. Jackson, David R. Frelinger, Michael J. Lostumo, and Robert W. Button. *Evaluating Novel Threats to the Homeland: Unmanned Aerial Vehicles and Cruise Missiles.* (Santa Monica, CA: RAND Corporation, 2008), 15.

[16]Ibid., 17.

[17]Ibid., xvii.

to include air-to-air combat, air-to-ground strafing, and tactical and strategic bombing. Higham concludes by restating that the outbreak of World War I caused the most significant advancement in aviation technology up to 1958.[18]

Historian R.G. Grant continues Higham's argument by stating that aircraft found their first practical use during World War I, while prior to 1914 they had no serious military or civilian role. Although aircraft only numbered in the hundreds prior to the war, they numbered in the thousands at the end. Daily operation of aircraft allowed for the growth and maturation of aviation through repeated testing over a short period. However, the greatest leap forward came because of improvements in engine power, airframe strength, and design competitions. Innovation and growth also came because of the financial motivations of contractors seeking funding. The war helped identify different roles for aircraft, and how the specialized aircraft designs that followed might support the commander on the ground. Grant concludes that World War I began the process of rapid aviation transformation, for both military and civil purposes. Significant steps came out of the development of long-range strategic bombing heralding changes in aviation including larger payloads, longer ranges, and the ferrying of passengers.[19]

Noted historians Peter Gray and Sebastian Cox compare the growth of airpower to an evolutionary process where "the course of airpower history has been punctuated by sudden periods of accelerated change."[20] Agreeing with Higham and Grant, they state that almost all forms of aviation in the twentieth-century were envisioned and worked out at some level between 1914-1918. Before World War I, military uses for aircraft remained speculative. They added that, "Those who want to understand the role of aircraft in subsequent conflicts do well to turn back to the experience of the Great War precisely because all the roots of modern practice are there to be explored."[21] Because of the experience of World War I, nations realized that airplanes

[18]Robin Higham, Air *Power: A Concise History*. (New York: ST. Martin's Press, 1972), 3-52.
[19]Reg G. Grant, Flight*: 100 Years of Aviation.* (New York: DK Publishing, 2002) 68-80.
[20]Sebastian Cox and Peter Gray eds., *Air Power History*. (Portland: Frank Cass Publishers, 2002), ix.
[21]Ibid., 3.

would be a critical component of any equation of future power. Understanding how the advent of airpower influenced warfare during World War I, and how this war provided the means for significant gains in aerial warfare tactics and airplane capabilities remains essential to this monograph's research on UAV development and proliferation. The following two paragraphs discuss growing UAV research and development, and state-sponsored use of UAVs through the lens of China's military transformation, and Hezbollah's war with Israel in 2006.

State and Non-State Actors

Carter and Perry state that China and the United States continue to pursue opposing national interests and military objectives. Because of this potential conflict, China is pursuing a revolution in military affairs with "Chinese characteristics."[22] This is something Sloan describes as a limited war under high-tech conditions.[23] They continue by describing the revolution as focused on copying characteristics of U.S. communications and command and control systems, and purchasing advanced technologies. Part of China's strategy is to modernize its airpower, which includes purchases of UAVs and associated technology. China hopes to match the United States' military power in the decades to come. Until that happens, it offsets any differences by exploiting America's technological vulnerabilities and mimicking its successes.[24] Sloan describes this tendency as countering U.S. technological dominance using asymmetric means, with UAVs as one method.[25]

From the perspective of a non-state actor, Hezbollah continues to demonstrate how a non-state actor can be effective against more powerful states, especially when supported by state actors. Cordesman, from the Center for Strategic and International Studies, conveyed evidence that UAVs used in the 2006 Israeli-Hezbollah war came from Iran. In addition, that Iran provided

[22]Ashton B. Carter and William J. Perry. "China on the March," March 2007, The National Interest Online, http://nationalinterest.org/commentary/china-on-the-march-1493 (accessed August 11, 2010).

[23]Elinor Sloan. *Military Transformation and Modern Warfare.* (Westport, CT: Praeger Security International, 2008), 95.

[24]Carter and Perry. "China on the March."

[25]Sloan, Military Transformation and Modern Warfare, 106.

command and control assistance to the Hezbollah Headquarters. Hezbollah's success against Israel came partially because of its application of asymmetric means such as UAVs and other slow moving, low-trajectory projectiles. Hezbollah took advantage of Israel's inability to track slow moving UAVs and forced Israel to improvise with existing systems in order to track low apogee and low-speed targets. The results of the Israeli-Hezbollah war demonstrate how the United States needs to develop defenses against UAV use, and to develop quick strike capabilities in order to destroy launchers for UAVs as quickly as possible.[26] Understanding how UAVs continue to develop, and their use by foreign powers, remains critical to comprehending the growing threat of UAVs and their use against U.S. deployed forces.

Summary

The growth and advancement of UAV technologies around the world continues to spread to numerous countries. The literature addresses the threat of terrorists and terror organizations using UAVs to conduct attacks against other nation states. Some literature addresses the spread of UAVs to state and non-state actors around the world. Historical literature provides an effective narrative describing challenges and successes experienced during the advent of airpower in World War I. However, no author addresses the threat of UAVs to deployed American forces, nor is any author providing recommendations for the U.S. military for how to counter the threat of UAVs in the future. This monograph intends to fill part of the gap in literature on this topic. By focusing on the future threat of UAVs, this paper provides historical context and practical recommendations for deploying American forces, as well as those forces not deploying but in a supporting role. The historical context becomes important to those involved in making decisions concerning how UAVs may develop, and provides background and understanding to those analyzing potential future threats.

[26]Cordesman. "Preliminary 'Lessons' of the Israeli-Hezbollah War."

Methodology

The primary goal of this study is to test the research question of whether the proliferation of UAVs increases the tactical and operational risk to deployed U.S. and allied forces, and the hypothesis that UAVs do increase the risk to deployed U.S. and allied forces. This section presents the methodology employed to test that hypothesis. This topic lends itself primarily to qualitative analysis because it requires subjective analysis of tightly controlled information concerning the capabilities of state, or non-state actors. In addition, much of the information collected pertains to civil and military uses of UAVs leaving the level of UAV threat, and U.S. defense capabilities against UAVs, open to debate. This section has four components: selection of significant cases, instrumentation, data collection, and data analysis.

Selection of Significant Cases

The research analyzes contemporary UAV threats to deployed U.S. forces. First, it explores the threat through a historical example of airpower growth in the Allied and Central Powers during World War I, compared to UAV growth from 1990 to the present. Then, it explores this potential threat through two state actors, and one non-state actor. The primary state actors evaluated in this monograph are China and Israel. Both countries display tremendous growth in UAV technology and marketing. China remains the primary state actor from a potential threat perspective, and Israel, though not a direct threat to the U.S., exports to foreign countries and risks greater proliferation of its technologies. Hezbollah remains the primary non-state actor threat on the global stage. Its deployment and moderately effective use of UAVs in its 2006 war with Israel displayed how non-state actors, supported by state actors, pose a credible UAV threat.

Instrumentation

This section describes the instrumentation by which the paper evaluates the foreign UAV threat. The first step is a direct comparison of UAV proliferation and advancement to the advent

and growth of airpower in World War I. It traces the turbulent beginning of airpower during World War I by discussing the mission and roles of airpower, as well as the manufacturing challenges faced by countries at the time. It also demonstrates how rapid proliferation of technology created an evolutionary leap forward in airpower through competition and proliferation. A comparison of UAV technological growth, as compared to World War I, follows this discussion in order to provide historical context to how UAVs are a developing threat. The next model used is the DOTMLPF model used by the joint U.S military forces to analyze force structure at all levels. However, Personnel and Facilities within DOTMLPF model will not be addressed, as they are either not central to the study, or they are adequately addressed in the other five categories. This paper applies the definitions in Joint or Army doctrine, and common definitions from dictionaries for those terms not defined in military doctrine. They are:

Doctrine - Fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgment in application.[27]

Organization - is the structuring of the armed forces of a state so as to offer military capability required by the national defense policy.[28]

Training - 1. The instruction of personnel to enhance their capacity to perform specific military functions and tasks.

2. The exercise of one or more military units conducted to enhance their combat readiness.[29]

Materiel - All items (including ships, tanks, self-propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property,

[27]Headquarters, United States Joint Forces Command. 2001. (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms*, Washington DC: Government Printing Office, 143.

[28]http://www.answers.com/topic/military-organization (accessed October 10, 2010)

[29]http://www.thefreedictionary.com/military+training (accessed October 10, 2010)

installations, and utilities) necessary to equip, operate, maintain, and support military activities without distinction as to its application for administrative or combat purposes.[30]

Leadership and Education - a. The process of influencing people by providing purpose, direction, and motivation, while operating to accomplish the mission and improve the organization.[31] **b.** Military education involves the professional preparation of officers to lead armed forces effectively in peace and war.[32]

Personnel - Those individuals required in either a military or civilian capacity to accomplish the assigned mission.[33]

Facilities - A real property entity consisting of one or more of the following: a building, a structure, a utility system, pavement, and underlying land.[34]

Although military in nature, the DOTMLPF model applies to any organization responsible for responding to airborne threats to the U.S. homeland, or deployed forces.

Data Collection

Historical data, professional journals, contemporary reviews of UAV technologies, and interviews provide the data for this research. Historical data applies to the discussion of World War I airpower growth among the Allied and Central Powers, as well as UAV growth. This section includes interview data from a university professor credited with establishing airpower research as a discipline. The review of state and non-state actors includes data from contemporary security, scientific, and defense journals as well as published books on military transformation. Interviews with educational, military, other federal government agencies, and the Research and Development Corporation (RAND) Corporation add to this data. The DOTMLPF

[30]Headquarters, United States Joint Forces Command. 2001. (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 286.

[31]Headquarters, Department of the Army. 2006. (FM) 6-22, *Army Leadership*, Washington DC: Government Printing Office, Glossary-3.

[32]http://www.answers.com/topic/military-education (accessed October 1, 2010).

[33]Headquarters, United States Joint Forces Command. 2001. (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 355.

[34]Ibid., 169.

model recommendations come from interviews with primarily military leadership, but also include some data from RAND, academia, and industry. All data collected is necessary to gain a proper historical context and understand how UAVs present a growing threat to U.S. forces.

Data Analysis

In this section, the research demonstrates how the data provides understanding and acknowledgement of growing UAV threats. The comparison of UAV to airpower growth during World War I incorporates common themes from historical data. It demonstrates how aircraft development in World War I and UAV development today are similar by focusing on mission, material, and tactics development. The scale for this analysis is yes or no, in that it either does, or does not provide the understanding claimed. The state and non-state actor analysis comprises triangulation of themes from interviews, journals, and books, as well as contemporary articles across a broad spectrum demonstrating a desire to use UAVs in potential or actual conflict. The scale for this analysis is also yes or no, in that the actor either demonstrates a threat or does not. The DOTMLPF analysis of current U.S. doctrinal concerns triangulates themes from multiple interviews in order to identify gaps and make recommendations to the joint forces to aid in countering current and future UAV threats. The scale for this analysis is poor, good, better, or best in that there are likely areas of success as well as needed improvements within the DOTMLPF analysis of the military's readiness in this case.

Summary

This section restated the purpose for this research. It then detailed the research methodology. The approach has three parts, beginning with an analysis of the advent of airpower in World War I compared to UAV growth. It then covers conceptual applications for UAVs followed by an analysis China's, Israel's, and Hezbollah's UAV growth and use, as well as intentions where possible. It concludes with a review of DOTMLPF recommendations from across the military, industrial, and academic sectors of the United States.

Analysis

This study intends to investigate the potential Unmanned Aerial Vehicle threat to deployed U.S. forces. It provides the results of historical research, reviews of multiple security and technology journals, and nine interviews conducted across the spectrum of academia, industry, and the Department of Defense. The research achieves its intended purpose by exploring how World War I airpower growth and proliferation among the Allied and Central Powers compares to UAV growth and proliferation today. It also examines conceptual uses for UAVs as well as state and non-state actors' current strategic considerations, UAV industrial status, and their way ahead in order to demonstrate how UAVs might be, or have been used in conflict. In addition, it conducts a DOTMLPF analysis of the United States military in order to identify its strengths and weaknesses in addressing foreign UAV threats. However, Personnel and Facilities are not addressed because they are either not central to the study, or they are adequately covered in the previous five categories. Finally, it provides recommendations for steps to take to improve in each DOTMLPF category.

To conduct the analysis it is important to answer or explore the following questions. Does the development and growth of airpower among the Allied and Central Powers in World War I provide an effective narrative for understanding how UAVs may develop and proliferate in the future? Around what conceptual framework could UAVs develop in the future and how could they conceptually employ against deployed U.S. or allied forces? Does an analysis of state and non-state actors assist in providing an understanding of the need for U.S. and allied forces to adapt to potential UAV threats? How well does the U.S. Armed Force's doctrine address potential UAV threats? How well does the U.S. Armed Force's organizational structure address potential UAV threats? Do the U.S. Armed Force's training programs adequately address potential UAV threats? Do the U.S. Armed Force's materiel solutions adequately address potential UAV threats? Do the leadership and education programs of the U.S. Armed Forces

adequately address potential UAV threats? What follows is a comparison of World War I aviation missions, capabilities, and aircraft proliferation to the UAV missions, capabilities, and proliferation today. Following this is a review of conceptual UAV uses against deployed U.S. or allied forces. Next is a review of state and non-state actors that describes their strategic considerations, what they have done, what they are doing, their tendency, and their potential. Finally, the research concludes with an analysis of DOTMLPF considerations for the joint services along with recommendations for improvement.

World War I Airpower Compared to UAVs

A comparison of the history of airpower's use by the Allied and Central Powers in World War I leads one to conclude that it is similar to the growth of UAVs in the last twenty years, especially since the United States' invasion of Iraq in March of 2003. If not for World War I, aviation might have remained in its infancy for a longer period, pursuing feats of glory in an attempt to treat airplanes more like an act at a circus rather than a platform for war, or a potential commercial enterprise. Similarly, largely due to U.S. success in Iraq and Afghanistan, the use of UAVs has progressed rapidly from remote control toys, to lethal and effective weapons of war, and to systems with significant potential for commercial applications. The growth of UAVs, specifically in the last ten years, is described as a "decade of discovery,"[35] or "a rapid chess game," where UAVs continue to develop over time, with nations competing for the latest in UAV and Counter-UAV technologies.[36] This evolution may not occur as rapidly as during World War I, but certainly, it will happen more rapidly "as soon as we get a state actor with resources up against us with some deep pockets."[37] The best way to compare the two is by comparing how World War I and UAV developments display similar evolutionary leaps in missions, capabilities, and proliferation.

[35]Donald A. Hazelwood, 2010, interview by author, Fort Leavenworth, KS, October 19, 2010.
[36]Keith A. Hirschman, 2010, interview by author, Fort Leavenworth, KS, October 5, 2010.
[37]Ibid.

World War I Missions

Airborne reconnaissance initially dominated the use of aircraft during World War I, but missions quickly moved beyond pure reconnaissance to bombing, strafing, air-to-air combat, and spotting for artillery fires. Prior to the war, self-imposed limitations on aircraft resulted primarily from the fact that most did not, or could not yet envision the capabilities of aircraft, or their potential roles. Thus, to win the air war, the airplane had to move from "an experimental vehicle into a weapon," in both air-to-air combat and air-to-ground missions.[38] In order to become an effective weapon, the airplane would have to demonstrate its value to commanders on the ground, then its demand would fuel commercial and design pursuits, and military contracts, as well as drive experimentation.

Therefore, in order to demonstrate broader utility to commanders, aircraft had to move beyond pure reconnaissance into ground attack, and bombing. For example, in 1911 Lieutenant Giulio Gavotti conducted the first known live bombing run in aviation history by placing grenades in a small satchel and dropping them out of the aircraft.[39] Similarly, pilots started filling their pockets with objects to throw, either at troops on the ground, or at each other.[40] Although a rudimentary beginning to air-to-air combat and ground attack and bombing, these tactics demonstrated to commanders the value of aircraft beyond pure reconnaissance. These tactics grew to the point where by 1917 aircraft operated in larger formations, sometimes up to forty aircraft, and began to bomb front line troops on a regular basis, as well as conduct low-level bombing raids on other key targets.[41]

In addition, air-to-air combat evolved out of a need to take away the advantage enjoyed by an enemy who freely roamed the skies. This led to the development of air-to-air combat flight

---

[38]Robin Higham and Dennis E. Showalter, eds. *Researching World War I: A Handbook.* (Westport, CT: Greenwood Press, 2003), 349.

[39]Curtis Prendergast, ed. *The First Aviators*. (Alexandria, VA: Time-Life Books, 198), 147.

[40]Peter I. Bosco, Antoinette Bosco and John S. Bowman. *World War I.* (New York: Facts on File, 2003), 105.

[41]Higham and Showalter, eds. *Researching World War I: A Handbook.*, 357.

tactics, forward and rear mounted machine guns, and aircraft with greater mobility dedicated to air-to-air combat missions. In addition, ground troops adapted to the new threat, and developed methods to engage airplanes in flight, arguably the formative stages of Air Defense Artillery. War thus assumed a third dimension, and commanders started to realize the significance of the capabilities aircraft provided to them.

UAV Missions

UAV missions developed along a similar path. Outfitted with small cameras, UAVs like the American Pioneer started out with the primary mission of daytime, low-altitude reconnaissance. Follow-on UAVs developed tactics and capabilities that included nighttime infrared reconnaissance, laser designation or targeting, long-distance communications relay, and direct missile engagements. A Hellfire engagement in Yemen in 2002 marked the beginnings of an armed UAVs ability to conduct precision targeting.[42] Today's UAVs have become one answer to missions that are, or potentially could be "dull, dirty, and dangerous."[43] These missions are either excessively long in duration; risky due to exposure to ground-fire or chemical, biological, radiological, or nuclear agents; or too far behind enemy lines to be feasible for manned aircraft. Occasionally, UAVs have become the first line of defense against modern threats where a low profile and low costs remain essential. In fact, Predator UAVs recently deployed to Yemen to hunt Al Awakli, a U.S. born Imam implicated in numerous terrorist plots in the United States.[44]

Other missions for UAVs continue to develop. The U.S. wars in Iraq and Afghanistan demonstrate the value of teaming manned aircraft with unmanned aircraft. This tactic called "Manned-Unmanned (MUM) Teaming" continues to become more habitual for deployed U.S. forces. In fact, the U.S. Army developed a unique test squadron out of Kiowa scout helicopters,

---

[42]"Sources: U.S. Kills Cole Suspect." November 5, 2002, CNN online, http://edition.cnn.com/2002/WORLD/meast/11/04/yemen.blast/index.html, (accessed August 10, 2010).

[43] Kimon P. Valvanis, ed. *Advances in Unmanned Aerial Vehicles.* (The Netherlands: Springer-Dortecht, 2007), 533.

[44]"US Predator UAVs Arrive at Secret Yemen Base to Hunt Awakli Down." Debkafile, November 9, 2010. http://www.debka.com/article/9135/printversion/ (accessed November 10, 2010).

and Shadow-200 UAVs in order to test for greater efficiencies for both aircraft.[45] In addition, the U.S., and China continue to develop mission specific Unmanned Combat Aerial Vehicles (UCAVs)[46] marking a transition from reconnaissance only missions to air-to-air combat and strategic bombing. The future could hold large formations of UAVs using "swarm" tactics, or conducting multi-platform deep strikes. Regardless, some have argued that UAVs "are another revolution in military affairs."[47]

World War I Capabilities

The missions of airplanes remained constrained by capabilities that continuously evolved to meet the demands of the customer. However, the ability of people to think of ways to use airplanes often seemed to outpace the technologies required to make their vision a reality. During World War I, airplanes capabilities were limited by the power and construction of the engine, airframe strength, and composition of surface materials.

> Their planes mere collages of wood, cloth and wire, were difficult to control and so sensitive to air currents that even moderate winds could knock them to the ground. The engines that pushed or pulled them were weak and unreliable, with a tendency to stop dead at crucial moments.[48]

In addition, the engines produced fumes that would occasionally knock pilots unconscious. Regardless, planes at the beginning of the war could only fly 60 miles per hour, and up to 5,000 feet, with limited range.[49] All of these factors combined to make airplanes unreliable and unable to carry large payloads, or go long distances. Therefore, the natural tendency was to relegate airplanes to reconnaissance, as this mission required the least power in terms of lift and maneuverability.

---

[45]"Helos Plus UAVs: U.S. Army to Test Squadron of Manned, Unmanned Aircraft." *DefenseNews* 25, no. 34 (September 13, 2010).

[46]An Unmanned Combat Aerial Vehicle is an unmanned attack aircraft controlled from the ground or the air. It is jet powered rather than propeller driven, and designed primarily to carry out airstrikes.

[47]Christopher Carlisle and Glen Rizzi. "Robot Revolution: Revealing the Army's UAS Roadmap," *Armed Forces Journal* 148, no. 1 (July/August 2010).

[48]Prendergast, ed. *The First Aviators*, 17.

[49]Bosco, Bosco, and Bowman. *World War I*, 104.

However, technological advances soon made airplanes more capable and reliable, and able to conduct a wider variety of missions. Competitions and experimentation created many of the advancements in airplanes that made it possible to assume greater mission variety. In 1913, London's Lord Northcliffe offered 10,000 pounds sterling to the first person able to fly across the Atlantic Ocean non-stop. Airplanes did not yet have the endurance or strength to complete the flight, so the money remained unclaimed. However, the experimentation that followed the announcement of these competitions advanced the airplane's capabilities significantly. Due to improvements in technology and capability, many of the rudimentary airplane tactics and missions begun in World War I still influence how aircraft are employed today.

UAV Capabilities

UAVs suffer from many of the same difficulties as early airplanes. Controllability problems, lack of engine power and reliability, limited fuel supply (gravity fed at times), and susceptibility to wind, rain, and other weather phenomena all combine to limit the types of missions UAVs could perform. Yet, designers continue to develop UAVs well beyond the point where they began. UAVs also began as propeller driven and have since moved on to jet engines. The smaller UAVs remain limited to lower altitudes due to fuel problems, or lack of deicing capability. However, larger UAVs now fly around the world, and occasionally stay aloft for months or years on end.

Competition also fosters a climate of experimentation and advancement for UAVs. The Association for Unmanned Vehicle Systems International (AUVSI) holds an annual UAV competition sponsored by companies like Northrop Grumman, Lockheed Martin, and the Office of Naval Research Science and Technology. Their 2004 competition had four times the number of participants of the previous year. The competition requires that systems navigate specified courses, use onboard sensor systems to identify objects, and return safely to the launch point.

Endurance and fuel use parameters all help determine the winners.[50] Open competition has allowed smaller U.S. companies, such as General Atomics and Aerovironment, who previously only worked on specialty projects to now compete with larger companies for UAV contracts.[51]

World War I Proliferation

Airplanes were not commonplace prior to World War I. In fact, when the war started there were an estimated 1,000 military aircraft in the world, with the bulk of those in France and Germany.[52] In comparison, nearing the end of WWI, General Pershing assembled 1,500 airplanes from the French and British in support of operations at St. Mihiel.[53] By the end of the war, the Western Front had over 8,000 airplanes, and the tactical units employed all grew in order to take advantage of larger forces.[54] Whereas a tactical unit used to be comprised of six airplanes it would now have 18, and other tactical units grew similarly. Soon after the war, a massive demobilization began, and the air forces became significantly smaller. However, the technology now existed and aviation soon spread to the commercial sector, and therefore around the world.[55]

World War I brought on a massive increase in the total numbers of aircraft in the world, as well as a larger variety of aircraft. Seaplanes appeared as well as crude forms of ship-based airplanes that would land in the water and be picked up by crane and placed on the ship; a crude form of future aircraft carriers with carrier launch airplanes dominating naval battles. Bombers with more powerful engines and greater ranges provided the foundation of commercial airline travel. Therefore, when the war ended, despite a massive demobilization effort, airplanes and the technology and industrial base supporting their manufacture turned to the civil sector where the technology continued to improve and spread.

---

[50]"UAV Competition," June 29, 2004. http://www.livingroom.org.au/uavblog/archives/uav_competition.php (accessed November 19, 2010).

[51]Hazelwood, 2010, interview by author.

[52]Higham and Showalter, eds. *Researching World War I: A Handbook,* 348.

[53]Bosco, Bosco and Bowman, 105.

[54]Higham and Showalter, eds. *Researching World War I: A Handbook,* 353.

[55]Ibid., 359.

UAV Proliferation

Just as World War I accelerated the process of development and acquisition of airplanes, the United States' invasion of Iraq in 2003 and Israel's continuing conflict with Hezbollah accelerated UAV development, acquisition, and interest on a global scale. For example, in October 2001 the United States Army maintained a small fleet of 54 unmanned aircraft, mostly smaller Hunter and Shadow systems. Nine years later, the U.S. Army has more than 4,000 UAVs consisting of small Ravens to the larger Extended-Range/Multi-Purpose armed UAV.[56] By adding in the United States Air Force, Navy, and Marine Corps, the total number of DOD UAVs increases to over 5,000.[57] Because of this rapid growth, the U.S. Army recently exceeded one million total flight hours, with approximately 900,000 of them in combat since 2001.[58]

In 2011, UAVs continue to spread to more countries. Some remain friends of the West, while some are potential adversaries. For example, there are approximately 151 different countries with UAVs, and 48 have active UAV programs.[59] The United States recently completed deals to sell Raven UAVs to Estonia, and continues to move forward with the intention of selling four Shadow UAV systems to Australia.[60] The U.S. and Israel remain in competition for sales of larger UAVs, such as the Globalhawk, to France.[61] In addition, Russia continues to sell arms to countries that the U.S. considers adversarial. When Israel and Russia recently signed a $400 million UAV deal for medium and short range UAVs, the potential for UAVs to appear in adversarial countries increased.[62] Combined with existing research already occurring, Russia should be able to catch up, and be a near-peer competitor in the UAV market in the next three to

[56]Carlisle and Rizzi. "Robot Revolution: Revealing the Army's UAS Roadmap," 32.
[57]Dyke Weatherington, 2010, interview by author, Fort Leavenworth, KS, October 25, 2010.
[58]Kris Osburn. "Army UAS Hit One Million Flight Hours," Eyes *Beyond the Horizon*, August 2010, 16.
[59]Hazelwood, 2010, interview by author.
[60]Steven Moore. "Foreign Military Sales Update." *Eyes Beyond the Horizon*, August 2010, 30.
[61]Pierre Tran. "France Expected to Pick MALE UAV in October," DefenseNews 25, no. 35 (September 20, 2010): 4.
[62]Barbara Opall-Rome. "Israel, Russia in $400M UAV Deal." *DefenseNews* 25, no. 39 (October 18, 2010): 1.

four years.[63] Another such country is Iran, which remains a concern to the United States. Iran currently has a significant UAV program, claiming that it also has stealth UAV capability.[64]

Ease of access to as well as a focused effort to gather U.S. UAV technologies clearly shows how interested other nations are in UAVs, and how easy it would be for state and non-state actors to acquire and use them. The U.S. Defense Security Service reported that continuous "suspicious collection" behavior seems to focus on America's UAV sector.[65] Further reports supported these claims, when evidence surfaced that over half of the countries in the world attempted to acquire U.S. UAV information during fiscal year 2008. With approximately 70% of the world's UAV research occurring in the U.S. in 2008, acquisition of these technologies will likely continue to spread UAVs globally.[66] In fact, China's Zhuhai Air Show recently displayed over 25 different UAVs, with many of them resembling Western UAVs in design and mission. This is "a remarkable number for a country that unveiled its first concept UAVs at the same air show only four years ago," and who is also likely to spur India and Japan to follow suit. A company official at the air show remarked that they were "interested in exporting them," and, "that's why we're displaying them here."[67] This demonstrates how easily existing UAV technology is acquired by other nations.

The analysis demonstrates that the comparison of World War I airpower to UAV growth and proliferation does provide understanding for how UAVs are likely to progress and proliferate to the point where they present a clear threat to deployed U.S. forces. Their mission

---

[63]Hazelwood, 2010, interview by author.

[64]"Bomb Kills Head of Iran's Military Drone Program." Debka online, August 16, 2010. http://www.debka.com/article/8971 (accessed August 18, 2010).

[65]Peter La Franchi. "East Asia remains focus of UAV spy activity as US Defence watchdog releases suspected espionage report." Flight Global. January 15, 2007. http://www.flightglobal.com/articles/2007/01/15/211541/east-asia-remains-main-focus-of-uav-spy-activity-as-us-defence-watchdog-releases-suspected.html (accessed August 10, 2010).

[66]David Perera. "Foreign Countries Want American UAV Secrets." Fierce Government IT online, April 6, 2010, http://www. fiercegovernmentit.com/story/foreign-countries-want-american-uav-secrets/2010-04-06, (accessed July 29, 2010).

[67]Jeremy Page. "China's New Drones Raise Eyebrows." The Wall Street Journal online, November 19, 2010. http://online.wsj.com/article/SB10001424052748703374304575622350604500556.html (accessed November 19, 2010).

development, increases in capabilities, and patterns of proliferation are virtually the same. However, the interconnected nature of the twenty-first century world, combined with speed of technology transfers, has the potential to accelerate the process of proliferation of UAV technologies. The future safety of U.S. forces requires the application of historical lessons learned from the growth of airpower in order to understand the nature of UAV threats, and potential countermeasures.

Concepts of UAV Use

In order to demonstrate the nature of the threat, a conceptual review for potential UAV applications against a deployed U.S. force is necessary. There are three broad categories of UAVs. First, there are small UAVs such as a Raven or Wasp, then tactical UAVs such as the Predator, and finally theater or strategic UAVs similar to the Globalhawk. All classes of systems have potential uses against U.S. forces.[68] There is growing evidence that near-peer competitors and terror groups intend to use UAVs in future attacks.[69] This assertion should come as no surprise; however, it should make those responsible for anticipating future threats consider how such states or organizations could use UAVs.

One method is to think of UAVs as "a poor man's guided missile."[70] Whether it is a high-end larger platform or low-end smaller platform, UAVs "might be able to be weaponized in a much more significant way,"[71] and become a one way weaponized UAV intended to loiter and find a target then destroy it. [72] In this case, small terror cells taking advantage of lower signature UAVs inflict uncertainty on U.S. forces in the same manner a Predator launches a Hellfire at a target while never being heard. State actors could also use this technique, but potentially on a larger scale. Additionally, the growing interest in rotary wing UAVs for crop dusting "raises all kinds of interesting questions with regards to using them for chemical or biological delivery

[68]See Appendix A for UAV Classifications.
[69]Gormley. "Addressing the Spread of Cruise Missiles and Unmanned Aerial Vehicles (UAVs)."
[70]Hirschman, 2010, interview by author.
[71]Brian Jackson, 2010, interview by author, Fort Leavenworth, KS, October 7, 2010.
[72]Adam R. Hinsdale, 2010, interview by author, Fort Leavenworth, KS, October 21, 2010.

methods."[73] Although not explosives delivery, a platform used in this type of attack would likely not return to a home station.

Another way to think of how states and organizations could use UAVs is to analyze the tactics of drug cartels along the U.S. and Mexican border. The cartels already use unmanned submarines, and boats. In fact, now they use ultra lights that "mimic UAVs in the early morning [under cover of darkness]; goggled, low, and slow flying."[74] In the future drug cartels could use UAVs to provide their own imagery, provide early warning of patrols, or to deliver drugs across the border with minimal risk. Considering the tactics used by the cartels provides a terrorism analyst with a good idea for how terrorists may deploy UAVs against U.S. forces in the future.[75]

Another use for UAVs is to exploit existing U.S. air-defense system weaknesses. The first method is to take advantage of an increasingly confusing and dense air defense "picture." During Desert Storm, the U.S. lost no aircraft to friendly fire incidents, and Patriot missile batteries successfully intercepted multiple ballistic missiles. However, Operation Iraqi Freedom showed some cracks in the system when Patriot batteries were unable to intercept low-flying threats, including two ultra-lights that flew over U.S troops while they moved north through Iraq.[76] A similar case is the successful shoot-down of an Iranian UAV in February of 2009. Although U.S. forces eventually shot the UAV down, the fact that a UAV flew out of Iran for as long as it did, created some challenges for existing airpower and air defense doctrine.

Another method is to "swarm" the system and causing multiple radar tracks that confuse operators and system software to the point of either inaction, or wrong action.[77] Some state actors appear to have the ability to create stealth platforms designed to operate with impunity in virtually any radar environment, however smaller UAVs could challenge air-defense systems as effectively as stealth UAVs due to their size and relative speed as well. The U.S. appears to be

[73]Dennis M. Gormley, 2010, interview by author, Fort Leavenworth, KS, October 5, 2010.
[74]Hazelwood, 2010, interview by author.
[75]Jackson, 2010, interview by author.
[76]Gormley. "Addressing the Spread of Cruise Missiles and Unmanned Aerial Vehicles (UAVs)."
[77]Basilio D. Bena, 2010, interview by author, Fort Leavenworth, KS, October 15, 2010.

developing a stealth UAV, however, Iran also claims to have a stealth drone called a Sofeh Mahi (Manta Ray), [78] and China displayed a UAV with stealth characteristics at a recent air show.[79] These cases demonstrate how an adversary could avoid much of the air defense network and attack its vulnerabilities.

In addition, the potential exists for networked drones to work together autonomously.[80] In this case, an adversary would be able to release multiple UAVs of any size, to include biologically inspired and micro-UAVs, in order to conduct multi-pronged attacks without having to maintain control. This type of potentially autonomous attack differs from a "swarm" attack in that a swarm could have multiple controllers whereas a networked attack might only have one, and only at the beginning stages. Next, an adversary could "tap into" existing UAV video, telemetry, or control frequencies. This capability already exists because U.S. forces admitted that insurgents viewed UAV video feeds, but not telemetry or control, in Iraq.[81] The purpose for this tactic could be to understand how U.S. forces gather intelligence, to understand where the U.S. is collecting intelligence, or to gather intelligence of their own for future attacks.

However, the danger also exists that adversaries could try to conduct jamming or spoofing on the UAV signal. In the case of jamming, the adversary attempts to scramble the signal of the UAV. The signal could be either a video frequency, or an aircraft control frequency with the intent to make the UAV crash, or to prevent its use. In the case of spoofing, an adversary over-rides the controlling frequency and takes control of the UAV.[82] In this case, a capable adversary could take control of a UAV and land it somewhere for exploitation of specific UAV systems, or onboard cryptological information. Another tactic is for an adversary to fly a UAV in proximity to forces with the intent of stimulating a response in order to judge reaction

[78]"Bomb Kills Head of Iran's Military Drone Program."
[79]Page, "China's New Drones Raise Eyebrows."
[80]Valvanis, *Advances in Unmanned Aerial Vehicles*, 541.
[81]Thomas Ricks. "Sharing Drone Feeds with the Enemy." Foreign Policy, December 18, 2009, http://ricks.foreignpolicy.com/posts/2009/12/18/sharing_drone_feeds_with_the_enemy (accessed July 28, 2010).
[82]Hazelwood, 2010, interview by author.

times or defensive techniques, and gather intelligence for future operations.[83] These concepts should help U.S. forces understand some methods UAVs might exploit current vulnerabilities.

State Actors

The two states analyzed in this section are China and Israel. First, each state has strategic considerations for UAV applications. In addition, the analysis focuses on what each state has done with UAVs, is doing with regard to UAV use and development, and their tendency and potential relative to UAV development and employment. States not included in this analysis, but worthy of mention are South Africa, Iran, the majority of the North Atlantic Treaty Organization (NATO) member states, Japan, South Korea, and Australia.

China continues to expand its military capabilities with the intention of modernizing its military, describing the process as a "Revolution in Military Affairs with Chinese Characteristics." Part of this modernization is the need for "informationalization," similar to the United States' C4ISR infrastructure whose technologies it seeks to analyze and copy.[84] Its first goal remains one of maintaining deterrence through ballistic missiles, but its second goal is to counter American dominance wherever possible. Dolman describes this consideration as the desire to either dominate, or contest the operational space.[85] If China is unable to dominate a given space, it will contest every space it can. As such, China continues to expand its capabilities in the air, with UAVs as one component of their greater strategy.[86] In fact, five of eight interviews conducted by the author specifically mention China as the number one threat. Therefore, China is "by far and away…the country of greatest concern," when it comes to UAV capabilities and anticipated intentions for use. [87]

---

[83]Jackson, 2010, interview by author.

[84]Nicholas Von Kospoth, ed. "Chinese Researchers Break Through the Mysteries of UAVs and UCAVs." Defense Professional online, October 14, 2009, http://mil.wms.kg/?p=509 (accessed August 15, 2010).

- C4ISR stands for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance.

[85]Everett C. Dolman. *Pure Strategy*. (New York: Routledge, 2005), 38-39.

[86]Carter and Perry. "China on the March."

[87]Gormley, 2010, interview by author.

In previous years, China focused on UAV acquisition and replication from other states. In 1994, Israeli Aerospace Industries (IAI) sold China the Harpy UAV, and it has used the platform in military exercises since. This UAV loiters while searching for targets, and then crashes into the target exploding 70 pounds of high explosives. In addition, the UAVs China initially produced mimicked the characteristics and the design of UAVs developed by other nations. China's initial desire for acquisition of existing platforms, as well as increased military funding now fuels its rapid UAV development programs.

China is an "up and coming force" in the global UAV market, and although challenged by trade restrictions, maintains the desire to gain self-reliance in UAV manufacturing.[88] China is enjoying success in its efforts to incorporate UAVs, as demonstrated by its display of ten short-range and mid-range UAVs during a recent National Day Parade. China's UAV development is not limited to smaller or tactical UAVs either. They continue to work on High-Altitude, Long-Endurance (HALE) platforms as wells as UCAVs such as the Dark Sword, a concept UCAV with stealth characteristics.[89] China also appears to be converting existing, first-generation, jets into crude UAV decoys in order to flood U.S. radar systems and potentially cause the U.S. to expend large numbers of expensive missiles,[90] creating challenges for identification of friendly versus unfriendly aircraft, as well as logistics.[91]

In addition to the HALE and UCAV systems, China is also working on multiple smaller-end tactical UAVs similar in mission and design to the American Raven and Wasp, or Shadow-200. Reconnaissance UAVs include the ChangHong-1, capable of up to 50,000 feet and 500 miles per hour; the "Sour Dragon," and the WuZhen-2000, similar to the American Global Hawk; and the ASN-207, a truck launched platform with a similar mission as the American Shadow-200

[88]Julius Yeo. "An Overview of the Asia Pacific Unmanned Aircraft Systems Market." Slide Share online, http://www.slideshare.net/FrostandSullivan/an-overview-of-the-asia-pacific-unmanned-aircraft-systems-market (accessed August 10, 2010).

[89]Peter La Franchi, "China's Dark Sword Unmanned Combat Air Vehicle Programme Raises Questions." October 17, 2007, http://www.flightglobal.com/articles/2007/10/17/218683/chinas-dark-sword-unmanned-combat-air-vehicle-programme-raises.html (accessed August 10, 2010).

[90]Gormley, 2010, interview by author.

[91]Erik Sofge. "China's Deadliest Game." *Popular Mechanics*, December 2010, 78-84.

system. The CH-3, medium-range, long-endurance (MALE) UAV, is still in development, but appears to be one of China's most complex systems, still able to carry weapons, and a large sensor suite. Finally, the Dark Sword UCAV, mentioned earlier, debuted as a concept at the Zuhai Air Show in 2006. This platform's capabilities include air-to-air combat, aerial intercept, and evasion of enemy radar using apparent stealth technology.[92]

China's tendency is to grow its UAV industry and reach out to other nations for technology and platforms. It looks for ways to counter American technological dominance, and should pursue UAVs that allow for deeper and more persistent operations. It also bases its concepts on Western platforms, and seeks to improve or modify them to its own needs.[93] Expect China to continue its investment in multiple UAV platforms as a means to contest or dominate the air, the radar environment, and intelligence gathering efforts.

China recently demonstrated its potential at the 2010 Zuhai air show where it displayed 25 different models of UAVs. Several designs fired missiles, and jet engines powered others. The display included a UAV capable of attacking targets within a 2000-kilometer radius.[94] "If China is successful in its efforts, it will not be too long before Chinese-made UAVs are seen over Asia Pacific's airspace," implying UAVs flying beyond China's borders and potentially throughout much of Asia, and into the Pacific Ocean.[95] In a Taiwan Straits scenario, China has the potential to use UAVs for intelligence, targeting, deception, and strategic bombing, rivaling its likely adversary in this scenario, the U.S.

Israel is another state actor displaying significant UAV capabilities. Its continuing conflict with Hezbollah, and need to focus on a hostile regional security situation, drives how Israel develops and acquires technology, and this is true for UAVs as well. Israel seeks to maintain a technological edge over its enemies in the region. In this context, UAVs provide

[92]Von Kospoth, ed. "Chinese Researchers Break Through the Mysteries of UAVs and UCAVs."
[93]Ibid.
[94]Page, "China's New Drones Raise Eyebrows."
[95]Yeo. "An Overview of the Asia Pacific Unmanned Aircraft Systems Market."

Israel with much needed early warning in order to allow maximum response time for a nation that controls little defensible territory. UAVs also allow Israel a more persistent reconnaissance platform that is cheaper and easier to use than satellite technology.

In fact, Israel outpaced the United States in UAV technology prior to 2003, and remains a significant actor in the UAV field.[96] Israel's 2006 conflict with Hezbollah provided it with numerous strategic, operational, and tactical lessons concerning UAV applications in a large-scale conflict. Searching for and destroying rocket firing points was a "principal task" for UAVs in this conflict. In addition, real time intelligence gathering served as a valuable addition to Israel's effort to locate resupply routes, "troop concentrations," and occasionally team with AH-64 gunship helicopters to identify, locate, track, and destroy targets.

Israel regards UAVs as a means to support its industrial complex. On a global scale, Israel supplies foreign governments with UAVs, over the objections of others in some cases. Israel recently signed a $400 million contract with Russia in order to provide UAV platforms, their supporting technology, and production knowledge. The deal includes kits for Searcher and I-bird UAVs.[97] Some assert that Israel's UAV capabilities are ahead of the United States, and continuously evolving even if on a smaller scale.[98] Israel also provided the majority of the information required for the U.S. to initiate the Pioneer UAV program, [99]and sold Harpy UAVs to China.[100] Reports indicate they sold UAVs to Turkey that assisted Syria in attacks against Kurdish "rebels."[101] They also recently signed contracts to work with France on a joint venture for developing and marketing UAVs.[102]

Israel's tendency is to advance research in UAVs, and play a significant role in the proliferation of many of the supporting technologies to governments around the world. It expects

[96]Hazelwood, 2010, interview by author.
[97]Opall-Rome. "Israel, Russia in $400M UAV Deal," 1.
[98]Hirschman, 2010, interview by author.
[99]Opall-Rome. "Israel, Russia in $400M UAV Deal," 1.
[100]Gormley, 2010, interview by author.
[101]Assad, "Syria massacres Kurds aided by Turkey's Israel-made drones."
[102]Tran. "France Expected to Pick MALE UAV in October," 4.

to develop UAV applications for use against threats such as Hezbollah, and other close threats in order to be able to keep persistent watch over potential adversaries and gain as much early warning as possible. However, Israel also views Iran as an "existential threat" to its existence, and what remains unknown is the extent to which Israel is developing long-range UAVs with the sole purpose of reaching Iran.

Israel maintains the potential to remain one of the top suppliers of UAVs and UAV supporting technology and industry. Its recent experiences with UAVs combined with knowledge gained from American experiences in Iraq and Afghanistan could provide it with the motivation to continue to develop UAVs capable of conducting strategic bombing operations in nations like Iran, Syria, or other regional threats. Israel's demonstrated technical expertise could allow it to use any of the conceptual UAV uses described in this paper.

Non-State Actors

Ease of access to technology, combined with the specific motivations and capabilities of many non-state actors ensures that UAVs will not remain solely a weapon of industrial states. The best example for a non-state actor in this case is Hezbollah. This is not to claim that other non-state actors will not pursue UAV technologies; however, others will certainly adopt the capabilities Hezbollah employs against Israel. Hezbollah has embraced the O-RMA or "Other Revolution in Military Affairs," where technologically inferior actors acknowledge the technological superiority of larger states, but learn how to take advantage of limited technology, gain parity, and maybe even win.[103] Thus, Hezbollah also adopted the idea that ultimate victory over Israel is a "victory by not losing," i.e. a war of attrition.[104]

In order to achieve success against Israel, Hezbollah maintains strong ties with Iran. One result of this relationship is Iran's ability to supply Hezbollah with higher technologies such as UAVs. In fact, that Iran supplied Hezbollah with UAVs came as a surprise to Israel when an

[103]Itai Brun. "While You're Busy Making Other Plans-the 'Other RMA.'" *Journal of Strategic Studies* 33, no. 4. (August 20, 2010), 547.

[104]Ibid., 558.

apparently unarmed Iranian manufactured UAV overflew Northern Israel in 2004 and 2005 not tracked by air defense for at least half an hour in the case of the 2004 flight.[105] Reports claim that, at the time of the first flight, Iran had provided Hezbollah with up to eight UAVs.[106] In addition, no country at the time had an efficient defense against smaller, low-flying UAVs, or low-trajectory airborne systems of any kind.[107] Proof of this problem came via the Hezbollah UAV when it provided pictures of an Israeli Patriot battery despite Israeli claims that there were no air defense systems in the area.[108] Israel's war with Hezbollah in 2006 further demonstrated the link between non-state actors supported by state actors when Hezbollah employed armed UAVs to collect intelligence on Israeli movements.[109]

The use of UAVs by Hezbollah has a tendency to "elevate the potential use of UAVs for state and non-state actors, to include militias."[110]

> Anybody with internet access or availability to print media is certainly aware of how the U.S. is using the systems. An innovative and creative enemy can come up with lots of ways to use UAVs. They are easy to acquire and train on. After a few hours, you have the rudimentary skills required to operate one of these systems.[111]

A string of recent attempts to use UAVs by multiple actors proves this point. Aum Shinrikyo planned to conduct a chemical attack using remote control helicopters in 1995. Osama bin Laden considered using remote control, explosives laden airplanes to attack President George W. Bush in 2001. The Revolutionary Armed Forces of Colombia maintained remote-controlled aircraft in their camps as discovered during a raid in 2002. The Palestinian Liberation Organization used toy importers to purchase hundreds of model planes in order to retrofit them with explosives and fly them into targets in Jerusalem. An inmate in Guantanamo Bay, Cuba admitted to being part of a plot to attack the British House of Commons with anthrax-laden drones. Israeli forces

---

[105]Gormley. "Globalization and WMD Proliferation Networks: The Case of Unmanned Aerial Vehicles as Terrorist Weapons," 1.
[106]Miasinkov. "Terrorists Develop Unmanned Aerial Vehicles."
[107]Ibid.
[108]Gormley, 2010, interview by author.
[109]Ibid.
[110]Hazelwood, 2010, interview by author.
[111]Weatherington, 2010, interview by author.

prevented a planned explosive-laden UAV attack on a Jewish settlement in 2004. The same month six senior activists in Hamas died when the UAV they planned to launch against Israel blew up prematurely.[112]

The answer to the question of whether an analysis of state and non-state actors assists in providing an understanding of the need for U.S. forces to adapt to potential UAV threats is yes. Hezbollah as a non-state actor provides understanding for how other non-state actors could use UAVs. The progress made by China and Israel provides understanding for how state actors' pursuit of technological solutions and UAV platforms increases the UAV threat to U.S. forces. The fact that a growing UAV threat exists, although clear at this point, does not guarantee that the United States and its military forces are unprepared to cope with the threat. In order to gain a better understanding for how ready U.S. forces are to face this threat, this paper applies the military's DOTMLPF analytical model.

Doctrine

The consensus is that doctrine poorly addresses the threat of UAVs to U.S. forces. Doctrine is important because it drives both the process of technology acquisition and tactics applied across the services. Experts within the Unmanned Warfare section of Under Secretary of Defense for Intelligence argue that, "the services have done a poor job of characterizing these [UAV] threats and the Combatant Commands have not yet recognized the problem either."[113] Current thinking remains focused on ISR and limited strike missions for UAVs, and "too little effort is being applied to non-materiel based solutions which might serve to expand potential UA[V] mission areas."[114] The military has not even started thinking about UAVs as aerial interceptors. Nor has it addressed how to counter a competitor's use of both developed and off the shelf UAVs, which drives our Counter-UAV doctrine.[115] Additionally, the military tends to

[112]Miasinkov. "Terrorists Develop Unmanned Aerial Vehicles."
[113]Gregory Kern, 2010, interview by author, Fort Leavenworth, KS, October 21, 2010.
[114]Ibid.
[115]Hinsdale, 2010, interview by author.

focus on force-on-force analysis and engagements. Although needed for the higher intensity conflict, it does not model well the wider range of potentials. [116] Therefore, the military must broaden its perspective to understand the wide range of options available to potential adversaries.

Within the Army, the aviation branch has not recognized the growth potential of foreign UAVs, and must think about further steps needed to Counter-UAV threats around the world. Additionally, the air defense community is taking a lot of risk and one Army UAV expert asserts that "maybe we are missing the boat on the threat that UAVs may pose just around the corner."[117] Finally, the Joint Fires Center of Excellence (JFCOE) is the Counter-UAV roles and missions proponency; however, they have not done much work towards developing the doctrine to support the mission.[118] This shows that the primary agency for UAV threat doctrine has not adequately addressed the UAV threat within existing doctrine.

Experts in non-proliferation, UAV research, and UAV threats assert that addressing the following recommendations is necessary in order to rectify the shortfalls in doctrinal considerations. First, "The military has to begin to grapple with the advent of UAVs as a serious threat," and, pay more attention to a future with rapid UAV growth.[119] It must think through the scope of the threat from the individual to the group.[120] Also, understanding its response compared to the threat is important and good doctrine helps to "bound the response" to something

---

[116]Weatherington, 2010, interview by author.

- The Director of the Joint Unmanned Aircraft Systems Center of Excellence, Brigadier General Jeff Colt supported these statements in an interview by asserting that adversary UAVs will be introduced in the joint operating environment, and that threat capabilities will continue to evolve. He also asserts that examination of the threat may allow the U.S. to find long-term solutions to counter the UAV threat. http://www.jfcom.mil/newslink/storyarchive/2010/pa112410.html (accessed November 26, 2010). Also, Navy Captain Greg Maguire, in a separate interview, states that many of the concepts for counter-UAV technologies have only been tested in modeling and simulations and the new counter-UAV exercise called "Blue Knight" begins to address that shortfall. (http://www.jfcom/mil/newslink/storyarchive/2010/pa111610.html (accessed November 26, 2010).

[117]Hirschman, 2010, interview by author.

[118]Hazelwood, 2010, interview by author.

[119]Gormley, 2010, interview by author.

[120]The Department of Defense has begun to take steps to address this challenge. In a recent project coordination white paper produced by JFCOM "Blue Knight" is described as a project based on a validated Joint Urgent Operational Need, which followed on the heels of the first published operational concepts produced by the JUAS-CoE in June of 2010. White paper emailed to author January 2011 titled: "BLUE KNIGHT Counter-Unmanned Aircraft Systems Test Support," undated. See Forest, Jason in "Other" section in bibliography.

based on the threat, rather than old habits, asserts a senior RAND scientist.[121] One potential method would be to accept risk by drawing a line based on the class of UAV employed. Additionally, it needs to start looking into air defense doctrine across all services and seriously consider how we counter UAV threats from the ISR to the one-way "poor man's guided missile" platform.[122] Thus, the military lacks doctrine addressing the UAV threat through air defense, base defense, and force protection.

Therefore, one UAV threat expert asserts that the best method to answer the challenges posed by these recommendations is to create a specific study to address the current and emerging future threat, at all levels, and by all system classes and types.[123] In addition, says a former Army UAV Product Manager, the Joint Fires Center of Excellence must accelerate the program of developing Counter-UAV doctrine. To accomplish this it must go back to history and analyze what happened during the growth of airpower, and apply the necessary doctrine to the UAV threat. Doctrine should include jamming and spoofing in order to provide options beyond "if it flies it dies," and expand to allow for capture and exploitation.[124]

Organization

How the military organizes is important because it ensures personnel, processes, and facilities remain focused on, and adequately funded and staffed for Counter-UAV research and doctrine development. However, the Department of Defense is poorly organized to address the UAV threat. Each service recognizes the threat to a greater or lesser extent, but UAV Task Forces at all levels remain stove piped. Therefore, two OSD UAV experts assert that no single organization in the Department of Defense is addressing this problem; therefore each service must do a better job of integrating their efforts.[125] In the Army, there was a fight over who would control UAVs; Military Intelligence, or Army Aviation? The Army concluded that the aviation

[121]Jackson, 2010, interview by author.
[122]Hinsdale, 2010, interview by author.
[123]Ibid.
[124]Hazelwood, 2010, interview by author.
[125]Kern, 2010, interview by author.
Weatherington, 2010, interview by author.

branch should maintain oversight of organizations using unmanned aircraft since they could affect lower-flying manned rotary wing aviation first. [126] This resulted in a focus on U.S. applications for UAVs rather than on how UAVs could emerge as a threat. This demonstrates how multiple organizations in the Army had a piece of the problem, but nobody had total oversight over U.S. UAVs, much less analyzing foreign UAV threats.

OSD and DOD UAV and unmanned warfare experts assert that considering the following recommendations is important in order to address organizational challenges within the DOD. One organization within the DOD should coordinate all Counter-UAV efforts.[127] This would assist in integrating UAV Task Forces from the services, maintaining a better coordinated and less diffuse process.[128] For the Army; the Military Intelligence, Science and Technology, Program Executive Office (PEO) Aviation, the Air Defense, and the Aviation Branch should be involved in Counter-UAV developments. [129] The equivalent of these branches in each service should address this problem in a similar manner. Additionally, a UAV threat expert at the Joint Unmanned Aerial Systems Center of Excellence (JUAS-COE) says the services should review the JUAS COE Counter-UAV CONOPS. [130] This would ensure the services have addressed known and potential threats, accounted for the threat within their organization, and responded appropriately to manage the threat.

Furthermore, an OSD UAV expert asserts that a single center with dedicated aircraft "would be invaluable in order to maintain current levels of joint interoperability and to further advance interoperability and joint doctrine."[131] A test facility of this type maintains those capabilities that transferred to the JUAS COE when the U.S. Air Force's Aviation Applied

---

- In Brigadier General Colt's November 24, 2010 interview he maintains that "no single system exists that does all elements of the joint engagement sequence as it applies to counter adversary UAS," and the "synergy of the joint forces' existing capabilities is clearly better than that of the individual parts. The more the services work together, the better and faster our validated solutions will be to face this type of future threat."

[126]Hazelwood, 2010, interview by author.

[127]Weatherington, 2010, interview by author.

[128]Ibid.

[129]Hazelwood, 2010, interview by author.

[130]Bena, 2010, interview by author.

[131]Kern, 2010, interview by author.

Technology Directorate (AATD) closed and the JUAS COE stood up.[132] Therefore, in order to fill this requirement, the JUAS COE should remain open and adequately funded regardless of the status of the Joint Forces Command (JFCOM). In fact, a former director of UAV systems for the U.S. Army argues that the JUAS COE personnel are "a national asset," and we cannot lose them.[133] Finally, organizations must build expertise on UAVs at multiple levels. One example would be to assign UAV experts to the Air Defense and Airspace Management (ADAM) section within every Army Brigade Combat Team.[134] Another would be to assign Counter-UAV experts to Combatant Command staffs around the world.[135] This demonstrates how dedicated testing and experimentation, and the retention of subject matter expertise can address UAV threats.

Training

Training to address Counter-UAV threats either does not exist, or is poor across all services. Training is important because it allows the services to simulate real combat scenarios with a foreign UAV threat. Training also exposes commanders and staffs at all levels to the methods and systems adversaries may use. First, OSD UAV experts agree that adequate joint training remains under-addressed, from both the tactical employment and the systems exploitation perspective.[136] Second, training remains limited to the most likely threats; however, it lacks a sound basis of analysis. Thus, "we are asking war fighters to be prepared for every contingency, however these systems have a wide variety of uses, posing a challenge for both planners and operators." Therefore, the result is to ask the war fighters to solve the problem on their own.[137] Third, a former Army UAV Product Manager assert that current training scenarios, such as Black Dart, tend to hide the real results and use people who have limited to no experience in the systems, and are therefore unable to replicate potential adversary tactics.[138] Finally, subject

[132]Hazelwood, 2010, interview by author.
[133]Ibid.
[134]Ibid.
[135]Bena, 2010, interview by author.
[136]Kern, 2010, interview by author.
[137]Weatherington, 2010, interview by author.
[138]Hazelwood, 2010, interview by author.

matter experts on Counter-UAV developments "are limited in number and not assigned to the various Combatant Command and service staffs."[139] Thus, a proper training focus, with the right trainers, remains necessary in order to address UAV threats.[140]

The majority of those interviewed for this research agree that the following recommendations are important in order to address Counter-UAV training challenges within the DOD. First, the combat training centers, like the Army's National Training Center, the Navy's Joint Task Force Exercise, and the Air Force's Red Flag, must incorporate opposing force UAVs into its scenarios.[141] This "would be very telling to see how the Opposing Force (OPFOR) uses them."[142] Surrogate UAVs used in pre-deployment training allow units to prepare for Counter-UAV use, and to review rules of engagement (ROE), standard operating procedures (SOPS), and concepts of operation (CONOPS).[143] An internationally recognized non-proliferation expert asserts that real world exercises and simulations must increase, "that would be my strongest recommendation, a lot more simulation, and exercises dealing with friendly fire."[144] Additionally, the Deputy Director of Unmanned Warfare for Acquisitions and Technology, within the OSD, states that a thorough review of potential threats prevents organizations from training on what they want, rather than on likely threats.[145]

Second, an Army UAV expert argues that incorporating the results of Counter-UAV exercises, such as Black Dart, with previous and following recommendations incorporated provides a more realistic scenario for deploying organizations. The Department of Defense does

---

- Black Dart is a counter-UAV field demonstration in China Lake, California.

[139]Bena, 2010, interview by author.

[140]In Brigadier General Colt's November 24, 2010 interview he asserts that financially constrained situations make it harder to gather all the assets needed for proper testing. However, he also states that "the right operators are what we really need to optimize this opportunity."

[141]Hirschman, 2010, interview by author. Bena, 2010, interview by author. Hinsdale, 2010, interview by author. Gormley, 2010, interview by author. Weatherington, 2010.

- The Army's National Training Center has been incorporating coalition and threat UAVs in scenarios since 2008, however their tactics and procedures mimic that of the United States.

[142]Hirschman, 2010, interview by author.

- In Brigadier General Colt's November 24, 2010 interview he discusses recent training initiatives success at putting adversarial UAVs into training scenarios, such as at the Army's Joint Readiness Training Center. He states that this step was able to "stimulate professional discussion."

[143]Bena, 2010, interview by author.

[144]Gormley, 2010, interview by author.

[145]Weatherington, 2010, interview by author.

not adequately incorporate, or disseminate the results of the Black Dart exercises.[146] In addition, more experienced personnel must operate UAVs in exercises like Black Dart, and at the combat training centers. "If you want to learn, make the enemy as smart, or smarter, than what you think is being used now."[147] Finally, develop a common training program for all services and fund it right now. [148] Any training program must then include the appropriate technology, as well as classes that are applicable to all services, and based on an understanding of the real versus the perceived threat.

Materiel

Materiel solutions are important because they provide commanders with the ability to counter the threat of UAVs while deployed. The majority of the recommendations and concerns expressed during interviews centered on the fact that no adequate doctrine exists to drive materiel solutions. Still, experts within the OSD maintain that very little funding to date is applied to Counter-UAV research.[149] Although UAV threat solutions are getting better, "more needs to be done."[150] Therefore, the DOD must analyze the threat and decide what technologies need immediate funding. Also, says a former Army UAV Product Manager, compare the current state of UAVs in the world to when aircraft first showed up and incorporate the material lessons learned from that era.[151] Without a comprehensive understanding of the threat, material solutions cannot adequately address the need.[152] Therefore, materiel solutions depend on a thorough review of the threat, the application of doctrine, and funding of research in order to ensure materiel solutions are adequate.

---

[146]Kern, 2010, interview by author.
[147]Hazelwood, 2010, interview by author.
[148]Ibid.
- In a November 22, 2010 interview, Brigadier General Colt asserted that many nations produce and employ UAVs, gaining sophistication, and these trends will likely increase in the future. He believes it would be "naïve not to believe that a learning, intelligent threat is not eventually going to try to utilize these systems in some asymmetric manner." http://www.jfcom.mil/newslink/storyarchive/2010/pa112210.html (accessed November 26, 2010).
[149]Ibid.
[150]Weatherington, 2010, interview by author.
[151]Hazelwood, 2010, interview by author.
[152]Weatherington, 2010, interview by author.

Existing, and future systems within the DOD should incorporate Counter-UAV technology. The Joint Strike Fighter should have a radar that not only has the mission of air-to-air and air-to-ground combat, but a signature support package allowing it to identify and locate most classes of UAVs.[153] Additionally, Dr. Gormley from the James Madison Center for Non-Proliferation studies states that:

> You have to have solutions that relate to the so-called Single Integrated Air Picture (SIAP), where all the services are sharing radar related data so that you can have multiple radar looks at a particular target at deeper ranges so you can have time to react to these threats. It has far less to do with technology than forcing the services to improve the data links. If it is left up to service prerogative, it will never get solved."[154]

Therefore, a comprehensive approach to air defense from aircraft to ground based radar systems is the best method for countering UAV threats.

Incorporating jamming and spoofing capabilities into existing military organizations is also important. This allows for a multi-service, multi-layered approach to disrupting adversary UAV attacks.[155] Finally, "we have to start thinking about Counter-UAV technologies on our platforms."[156] UAVs already have the capability to carry payloads with sensor suites, weapons, and to loiter for extended lengths of time. As doctrinal and materiel solutions continue to develop, consideration should be given to what systems can go on UAVs to help with the Counter-UAV mission.

Leadership and Education

Education concerning the threat of UAVs is poor across all services, with some limited improvement. "Knowledge of the threat is limited at the Combatant Command staff level, and depends on the visible threat."[157] The fact remains that "there is only a small cadre that understands" UAVs.[158] Therefore, say OSD UAV experts, the education process starts at the top

[153]Hinsdale, 2010, interview by author.
[154]Gormley, 2010, interview by author.
[155]Hazelwood, 2010, interview by author.
[156]Hirschman, 2010, interview by author.
[157]Bena, 2010, interview by author.
[158]Kern, 2010, interview by author.

when organizations decide these systems pose a real threat.[159] Ultimately, education is essential, and the Department of Defense needs to conduct a crosscutting study between Acquisition, Technology, and Logistics (AT&L) and other appropriate agencies to determine the threat to U.S. forces. It must look at the threat from both large scale ISR and weaponized platforms. AT&L deals with all the Product Managers (PMs) at the Office of the Secretary of Defense (OSD) level and has some unique capabilities to look at future threats.[160] This means that the DOD must continue to look at UAV threats as real; and educate commanders, staffs, and personnel at all levels so they address UAV threats adequately.

Two examples demonstrating the lack of UAV threats in education is to look at the Army's Command and General Staff College, Intermediate Level Education (ILE) curricula, and the Captain's Career Course curricula for the Aviation, Military Intelligence, and Air Defense Branches. The ILE curriculum does not address the threat of foreign UAVs in any of its core, advanced, or elective curricula. UAVs in ILE are discussed only in the context of American systems supporting U.S. forces. Similarly, in the three Captain's Career Courses in the Army, UAV threats are not discussed, and UAVs are only discussed in how American systems support U.S. forces.

Summary

Within the topic of UAV threats to deployed U.S. forces, there were four cases studied. First, a comparison of UAV growth and proliferation to the growth and proliferation of airpower during World War I from the perspective of missions, materiel developments, and proliferation. Second is an analysis of the state actors of China and Israel and their strategic applications, as well as UAV development tendencies and potentials. Third, an analysis of the non-state actor Hezbollah demonstrated how such an actor, supported by a state actor, can effectively use UAVs in a conflict, and provide motivation for other non-state actors to pursue and employ UAVs.

[159]Weatherington, 2010, interview by author.
[160]Hinsdale, 2010, interview by author.

Finally, a doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) analysis examined how effectively the United States' military solutions address the growing UAV threat. The result of the case studies demonstrated that the threat of UAVs to U.S. forces is growing larger every year, and the military does not appear prepared to meet the challenge.

Conclusion

America's use of UAVs during its wars in Afghanistan and Iraq provided the fuel for a fire that started with the advent of target drones and remote control planes, and then progressed to the Pioneer, the Predator, and the Reaper, as well as more advanced systems still in development. The proliferation of UAVs has already begun to spread around the world. This paper began by outlining the research's background and importance, reviewed the primary literature covering this topic, and then outlined a methodology for the paper's research. The analysis consisted of a comparison of World War I airpower evolution and proliferation to UAV evolution and proliferation. Second, it provided conceptual uses for UAVs against U.S. forces. Third, it analyzed selected state and non-state actors for their strategic application of UAVs, past and present UAV development, as well as their tendencies and potentials. Finally, it provided an analysis of current service DOTMLPF considerations in order to identify strengths and weaknesses, as well as provide recommendations to address any weaknesses.

First, a comparison of World War I airpower and UAVs provided an understanding for how UAVs may develop and proliferate in the future. UAVs and airplanes evolved along similar lines of development. Both started life with limited capability for power, speed, and lift. Both started with basic reconnaissance missions and rapidly moved to tactical and strategic bombing missions. Both had challenges regarding airframe strength, susceptibility to weather, weaponization, and technological development keeping pace with ideas for application. Finally, both started in a small number of countries and rapidly proliferated to numerous countries as the

technology became cheaper and more accessible, and as other countries witnessed the demonstrated successes of airpower applications and realized the need to develop airpower in order to compete.

Second, the research showed UAV Concepts of Use in order to demonstrate potential UAV uses against U.S. forces in the future. Use of UAVs ranged from near-peer competitors application of UAVs for reconnaissance, targeting, bombing, and potential air-to-air engagements to retrofitted older planes designed to confuse or overwhelm air defense systems. Other state actor uses included direct or indirect support to non-state actors, and a desire to achieve low-cost solutions to a potential competitor's technological dominance. Non-state actor's use of UAVs ranged from the use of UAVs as a poor man's guided missile, to the desire to provoke specific reactions. Additionally, their potential use included the spread of chemical or biological weapons, or as a platform to covertly more illicit materials with low risk to the organization or its people.

Third, an analysis of state and non-state actors provided understanding of the need for U.S. forces to adapt to potential UAV threats. The strategic considerations for China, Israel, and Hezbollah all demonstrated a desire to pursue UAVs in order to counter an enemy they considered technologically superior, or who needed to gain the earliest warning possible. The same actors demonstrated a history of pursuing technology to counter an adversary's technological edge, including continuing pursuit of UAVs. Finally, each actor demonstrated a strong tendency to continue to pursue UAVs, and the potential to use UAV in multiple ways, including in a larger state-on-state conflict and in support of insurgencies or terrorist groups.

Finally, a DOTMLPF analysis of military doctrine demonstrated that the services are poorly equipped to deal with foreign UAV threats. Doctrinally, the services lack a comprehensive review of the threat in order to drive other solutions. Organizationally, the services remain "stove piped," not working together to provide more comprehensive solutions. Training is lacking at all levels. Specifically, exercises do no incorporate enough UAV threats,

and UAV specific exercises do not adequately represent the range of the threat. Nor are the results of UAV specific exercises shared with the other services. Materiel solutions show improvement, but due to the lack of a comprehensive doctrinal review, they remain limited to best guess solutions. Leadership, through education, must address the real threat UAVs pose to U.S. forces. UAV subject matter expertise must grow at all levels, from Combatant Command down to the Army Brigade Combat Team, or the equivalent in the other services. Facilities, such as the JUAS-COE must remain open and receive adequate funding to continue pursuing solutions that have geometric affects across all services.

This research did not address all possible concerns relating to the threat of UAVs to U.S. forces, due to limitations in space and time. However, the following research topics are encouraged. First, analyze air defense development as it relates to the beginning of airpower in World War I. This research could identify the lessons learned and steps taken by the air defense community in order provide air defense recommendations or solutions to the services possibly assisting them in countering UAV threats. Second, a review of U.S. airpower doctrine in order to identify the specific employment tactics, techniques, or procedures UAVs might use in the future. Ultimately, the services must recognize the threat UAVs pose to U.S. forces now, and the potential they could pose in the future. Eliot Cohen could be right about this being the next Revolution in Military Affairs. Therefore, the U.S. military needs to remain ahead of the world in UAV and Counter-UAV technologies, otherwise the potential exists that it may lose its ability to dominate the air, what then?

Appendix 1

Table 1. Joint UAS Groups

UAS Category	Weight	Altitude	Speed
Group 1 (Raven)	Less than 20 pounds	Less than 1,200 feet AGL	Less than 100 knots
Group 2 (No U.S. system fielded)	21-55 pounds	Less than 3,500 feet AGL	Less than 250 knots
Group 3 (Shadow)	Less than 1320 pounds	Less than 18,000 feet AGL	Less than 250 knots
Group 4 (Predator)	Over 1320 pounds	Less than 18,000 feet AGL	Any speed
Group 5 (No U.S. system field)	Over 1320 pounds	Over 18,000 feet AGL	Any speed

Source: Created by author using data from, *FY2010–2035 Unmanned Aircraft Systems Roadmap*, Department of Defense, 2010.

Table 1. Multi-Service UAS Classifications

Classification	Size	Altitude	Characteristics
Man-Portable UAS (Raven or Wasp)	Small, self-contained	Below coordinating altitude	-controlled at the combat team level. -Data is usually FMV constrained by LOS. -Data may be disseminated to brigade/battalion TOCs. -Imagery processing/interpretation is limited to the combat team.
Tactical UAS (Shadow)	Larger systems with more robust requirements	Above coordinating altitude	-Operated by specialized UAS units. -Products can expand beyond FMV depending on payload. -Imagery processing/interpretation may be conducted by intelligence units. -Communication may be LOS dependant.
Theater UAS (Predator, Reaper, Globalhawk)	Large systems	Above coordinating altitude	-Operated by specialized UAS units. -Numerous products available depending on payload. -Imagery processing/interpretation may be conducted by local intelligence units or reach back intelligence organizations. -BLOS Communications.

Source: Created by author using data from, *Multi-Service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aerial Systems*, Headquarters, Department of the Army, 2006.

Bibliography

Books

Bosco, Peter I., Antoinette Bosco, and John S. Bowman. *World War I.* New York: Facts on File, 2003.

Boyne, Walter J. *The Influence of Air Power Upon History.* New York: Pelican Publishing Company, 2003.

Cox, Sebastian, and Peter Gray, eds. *Air Power History.* Portland: Frank Cass Publishers, 2002.

Daly, Mark, and Martin Streetly, eds. *Jane's Unmanned Aerial Vehicles and Targets.* Alexandria: Jane's Information Group Inc., 2008.

Dolman, Everett C., Pure *Strategy*. New York: Routledge, 2005.

Dombrowski, Peter, and Eugene Gholz. *Buying Military Transformation: Technological Innovation and the Defense Industry.* New York: Columbia University Press, 2006.

Falkenrath, Richard A., Robert D. Newman, and Bradley A. Thayer. *America's Achilles Heel: Nuclear, Biological, and Chemical Terrorism and Covert Attack.* Cambridge: The MIT Press, 1998.

Gerstein, Daniel M. *Securing America's Future: National Strategy in the Information Age*. Westport: Praeger Security International, 2005.

Grant, Reg G. *Flight: 100 Years of Aviation.* New York: DK Publishing, 2002.

Higham, Robin. *Air Power: A Concise History.* New York: St. Martin's Press, 1972.

Higham, Robin. *100 Years of Air Power and Aviation.* College Station: Texas A&M University Press, 2003.

Higham, Robin, and Dennis E. Showalter, eds. *Researching World War I: A Handbook.* Westport: Greenwood Press, 2003.

Horwood, Ian. *Interservice Rivalry and Airpower in the Vietnam War*. Fort Leavenworth: Combat Studies Institute Press, 2006.

Jackson, Brian A., David R. Frelinger, Michael J. Lostumo, and Robert W. Button. *Evaluating Novel Threats to the Homeland: Unmanned Aerial Vehicles and Cruise Missiles.* Santa Monica: RAND Corporation, 2008.

Mandel, Robert. *Global Threat: Target-Centered Assessment and Management.* Westport: Praeger Security International, 2008.

Matthews, Matt M. *We Were Caught Unprepared: The 2006 Hezbollah-Israeli War*. Fort Leavenworth: Combat Studies Institute Press, 2008.

Prendergast, Curtis, ed. *The First Aviators*. Alexandria: Time-Life Books, 1981.

Singer, P.W. *Wired for War: The Robotics Revolution and Conflict in the Twenty-first Century*. New York: The Penguin Press, 2009.

Slessor, J.C. *Air Power and Armies.* London: Oxford University Press, 1936.

Sloan, Elinor. *Military Transformation and Modern Warfare.* Westport: Praeger Security International, 2008.

U.S. Army. *U.S. Army Roadmap for UAS 2010-2035*. Fort Rucker: U.S. Army Unmanned Aerial Systems Center of Excellence, 2010.

Valvanis, Kimon P., ed. *Advances in Unmanned Aerial Vehicles.* The Netherlands: Springer-Dortecht, 2007.

Articles

Assad, Bashar. "Syria massacres Kurds aided by Turkey's Israel-made drones." Debkafile online. July 17, 2010. http://www.debka.com/article/8916/ (accessed July 18, 2010).

BBC News. "Russia 'shot down Georgia drone'." BBC online. April 21, 2008. http://news.bbc.co.uk/2/hi/europe/7358761.stm (accessed August 10, 2010).

"Bomb Kills Head of Iran's Military Drone Program." Debkafile online. August 16, 2010. http://www.debka.com/article/8971 (accessed August 18, 2010).

Carlile, Christopher V., and Glen Rizzi. "Robot Revolution." Armed Forces Journal, July/August 2010.

Carter, Ashton B., and William J. Perry. "China on the March," March 2007, The National Interest Online. http://nationalinterest.org/commentary/china-on-the-march-1493 (accessed August 11, 2010).

Sofge, Erik. "China's Deadliest Game." *Popular Mechanics*, December 2010.

CBS News Investigates. "Palestinian militants try to find ways to overcome Israeli UAVs on Jihadi forums." 31 December 2008. http://www.cbsnews.com/8301-502684_162-4693780-502684.html?tag=contentMain%3bcontentBody (accessed August 10, 2010).

Egozi, Arie. "Israel Praises UAV Abilities during Operation Change of Direction anti-Hezbollah Lebanon Campaign." *Flight International*, August 29, 2006.

Eshel, David. "Israel intercept two attack UAV launched by Hezbollah." August 7, 2006. http://defense-update.com/2006/08/israel-intercept-two-attack-uav.html (accessed 10 August 2010).

Glade, David. "Unmanned Aerial Vehicles: Implications for Military Operations," Occasional Paper No. 16. Center for Strategy and Technology, Maxwell Air Force Base, AL: United States Air Force Air War College, 2000.

Gonzalez, Gregory B. "One Million and Counting." *Eyes Beyond the Horizon*, August 2010.

Gormley, Dennis M. "Addressing the Spread of Cruise Missiles and Unmanned Aerial Vehicles (UAVs)" Center for Nonproliferation Studies (CNS), Washington, D.C., March 2004. http://www.nti.org/e_research/e3_39a.html (accessed August 10, 2010).

"Iranian Aircraft Down In Flames Over Iraq." Strategy Page online, March 19, 2009, http://www.strategypage.com/htmw/htairfo/articles/20090319.aspx (accessed August 10, 2010).

"Ambassador of Death" Unmanned Bomber Released in Iran." Fox News online, August 22, 2010. http://www.foxnews.com/slideshow/world/2010/08/22/ambassador-death-unmanned-bomber-released-iran/#slide=1 (accessed August 23, 2010).

"Iranian UAVs Monitoring US Navy in Persian Gulf." January 13, 2008. http://www.liveleak.com/view?i=c2e_12002 15726 (accessed August 10, 2010).

La Franchi, Peter. "China's Dark Sword Unmanned Combat Air Vehicle Programme Raises Questions." October 17, 2007, http://www.flightglobal.com/articles/2007/10/17/218683/chinas-dark-sword-unmanned-combat-air-vehicle-programme-raises.html (accessed August 10, 2010).

La Franchi, Peter. "East Asia remains focus of UAV spy activity as US Defence watchdog releases suspected espionage report." Flight Global. January 15, 2007. http://www.flightglobal.com/articles/2007/01/15/211541/east-asia-remains-main-focus-of-uav- spy-activity-as-us-defence-watchdog-releases-suspected.html (accessed August 10, 2010).

LeCappelain, Josh. "Blue Knight 2010 kicks off at Nellis Air Force Base." November 16, 2010. http://www.jfcom/mil/newslink/storyarchive/2010/pa111610.html (accessed November 26, 2010).

LeCappelain, Josh. "Blue Knight 2010 demonstration concludes in Nevada." November 22, 2010. http://www.jfcom/mil/newslink/storyarchive/2010/pa112210.html (accessed November 26, 2010).

LeCappelain, Josh. "Newsmaker Profile: Army Brig. Gen. Jeff Colt." November 24, 2010. http://www.jfcom/mil/newslink/storyarchive/2010/pa112410.html (accessed November 26, 2010).

Miasnikov, Eugene. "Threat of Terrorism Using Unmanned Aerial Vehicles: Technical Aspects," Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, Dolgoprudny, June 2004. http://207.5.18.146/UAV/UAV-report.pdf (accessed August 11, 2010).

Miasinkov, Eugene. "Terrorists Develop Unmanned Aerial Vehicles," Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, Dolgoprudny, December 6, 2004. http://*www.armscontrol.ru/uav/mirsad1.htm* (accessed August 11, 2010).

"Media Reports of Terrorist Attempts to Employ UAVs." Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, Dolgoprudny, March 6, 2005. http://www.armscontrol.ru/uav/clips.htm (accessed August 11, 2010)

Moore, Steven. "Foreign Military Sales Update." *Eyes Beyond the Horizon*, August 2010.

Mwesigwa, Steven. "Predator and Reaper Advancement in Combat Capabilities." Air Land Sea Bulletin, September 2009.

Myers, Lisa. "Hezbollah Drone Threatens Israel." MSNBC online, April 12, 2005. http://www.msnbc.com/id/7477428 (accessed August 15, 2010).

Norland, Rod, and Alissa J. Rubin. "U.S. Says It Shot Down an Iranian Drone Over Iraq." New York Times Online. March 16, 2009. http://www.nytimes.com/2009/03/17/world/middleeast/ 17iraq.html? (accessed August 10, 2010).

Osburn, Kris. "Army UAS Hit One Million Flight Hours." *Eyes Beyond the Horizon*, August 2010.

Perera, David. "Foreign Countries Want American UAV Secrets." Fierce Government IT online, April 6, 2010, http://www.fiercegovernmentit.com/story/foreign-countries-want-american-uav-secrets/2010-04-06, (accessed July 29, 2010).

Reid, Robert H. "Iranian drone shot down by US over Iraq: military admits." March 16, 2009. http://www.huffingtonpost.com/2009/03/16/iranian-drone-shot-down-b_n_175375.html (accessed August 10, 2010).

Ricks, Thomas. "Sharing Drone Feeds with the Enemy." Foreign Policy, December 18, 2009, http://ricks.foreignpolicy.com/posts/2009/12/18/sharing_drone_feeds_with_the_enemy (accessed July 28, 2010).

Ricks, Thomas E. "U.S. Arms Unmanned Aircraft." Washington Post online, October 18, 2001. http://www.washingtonpost.com/ac2/wp-dyn/A12129-2001Oct17?language=printer (accessed August 16, 2010)

Royal Air Force Organization. "The development of British military aviation." M. B. Barrass. http://www.rafweb.org/RAF_History.htm (accessed 10 August 2010).

Singer, P.W. "Defending Against Drones: How our new favorite weapon in the war on terror could soon be turned against us." Newsweek Online. February 25, 2010, http://www.newsweek.com/2010/02/25/defending-against-drones.html (accessed August 10, 2010).

"Sources: U.S. Kills Cole Suspect." November 5, 2002, CNN online, http://edition.cnn.com/2002/WORLD/meast/11/04/yemen.blast/index.html, (accessed August 10, 2010).

"US Predator UAVs Arrive at Secret Yemen Base to Hunt Awakli Down." Debkafile, November 9, 2010. http://www.debka.com/article/9135/printversion/ (accessed November 10, 2010).

Von Kospoth, Nicholas, ed. “Chinese Researchers Break Through the Mysteries of UAVs and UCAVs.” Defense Professional online, October 14, 2009, http://mil.wms.kg/?p=509 (accessed August 15, 2010).

Weinberger, Sharon. “Anyone, Anywhere, Anytime.” *Popular Science*, September 2010.

Weiss, Efrat. "Hizbullah drone shot down over Israel." ynet news. August 7, 2006. http://www.ynetnews.com/articles/0,7340,L-3287862,00.html (accessed 23 October 2009).

Whittle, Richard. “ROTORCRAFT UAVs.” *rotor&wing*, August 2009.

Wise, Jeff. "Civilian UAVs: No pilot, no problem.” Popular Mechanics. April 2007. http://www.popularmechanics.com/science/space/4213464 (accessed 22 October 2009).

Yeo, Julius, “An Overview of the Asia Pacific Unmanned Aircraft Systems Market.” Slide Share online, http://www.slideshare.net/FrostandSullivan/an-overview-of-the-asia-pacific-unmanned-aircraft-systems-market (accessed August 10, 2010).

Journals

Armada International. *Complete Guide to Drones 2009*. Zurich: Armada International.

Brookes, Andrew. “Air War Over Lebanon.” *The International Institute for Strategic Studies*. August 8, 2006. http://www.iiss.org/programmes/defence-and-military-analysis/about/analysis- archive/air-war-over-lebanon/ (accessed August 10, 2010).

Brun, Itai. “While You’re Busy Making Other Plans-the ‘Other RMA.’” *Journal of Strategic Studies* 33, no. 4 (August 20, 2010).

Carlisle, Christopher, and Glen Rizzi. “Robot Revolution: Revealing the Army’s UAS Roadmap.” *Armed Forces Journal* 148, no. 1 (July/August 2010).

Congressional Research Service. CRS Report for Congress, “Unmanned Aerial Vehicles: Background and issues for Congress.” Washington DC: Foreign Affairs, Defense, and Trade Division. (2005)

Cordesman, Anthony H. “Preliminary ‘Lessons’ of the Israeli-Hezbollah War.” *Center for Strategic and International Studies* (August 17, 2006). http://csis.org/files/media/csis/pubs/060817_isr_hez_lessons.pdf (accessed August 10, 2010).

Gormley, Dennis M., and Richard Speier. “Controlling Unmanned Air Vehicles: New Challenges,” *The Nonproliferation Review* 10, no. 2 (Summer 2003).

Gormley, Dennis M. “UAVs and Cruise Missiles as Possible Terrorist Weapons,” in James Clay Moltz, ed., New Challenges in Missile Proliferation, Missile Defense, and Space Security, *Occasional Paper No. 12*. Monterey, CA: Monterey Institute’s Center for Nonproliferation Studies, (2003).

Gormley, Dennis M. "Globalization and WMD Proliferation Networks: The Case of Unmanned Aerial Vehicles as Terrorist Weapons," *Strategic Insights* V, no. 6 (July 2006).

Gormley, Dennis M. "Testimony Before the Subcommittee on National Security, Emerging Threats, and International Affairs of the U.S. House of Representatives Committee on Government Reform," (March 2004). http://cns.miis.edu/testimony/testgorm.htm (accessed August 10, 2010).

"Helos Plus UAVs: U.S. Army to Test Squadron of Manned, Unmanned Aircraft." *DefenseNews* 25, no. 34 (September 13, 2010).

Matthews, William. "Border Predators: U.S. Puts UAVs to Work Along Mexico Boundary." *DefenseNews* 25, no. 34 (September 20, 2010).

Matthews, William. "Global Observer Takes Off: Long Flying UAV Will Perform Missions From Loftier Heights." *DefenseNews* 25, no. 30 (August 23, 2010).

Matthews, William. "Sharing Airspace Safely." *DefenseNews* 25, no. 35 (October 4, 2010).

Opall-Rome, Barbara. "Israel, Russia in $400M UAV Deal." *DefenseNews* 25, no. 39 (October 18, 2010).

Page, Jeremy. "China's New Drones Raise Eyebrows." The Wall Street Journal online, November 19, 2010. http://online.wsj.com/article/SB10001424052748703374304575622350604500556.html (accessed November 19, 2010).

"Record Breaking Flight." *DefenseNews* 25, no. 33 (September 6, 2010).

Tran, Pierre. "France Expected to Pick MALE UAV in October." *DefenseNews* 25, no. 35 (September 20, 2010).

Interviews

Bena, Basilio D., 2010, interview by author, Fort Leavenworth, KS, October 15, 2010.

Gormley, Dennis M. 2010, interview by author, Fort Leavenworth, KS, October 5, 2010.

Hazelwood, Donald A., 2010, interview by author, Fort Leavenworth, KS, October 19, 2010.

Higham, Robin, 2010, interview by author, Fort Leavenworth, KS, October 10, 2010.

Hinsdale, Adam R., 2010, interview by author, Fort Leavenworth, KS, October 21, 2010.

Hirschman, Keith A., 2010, interview by author, Fort Leavenworth, KS, October 5, 2010.

Jackson, Brian, 2010, interview by author, Fort Leavenworth, KS, October 7, 2010.

Kern, Gregory, 2010, interview by author, Fort Leavenworth, KS, October 21, 2010.

Weatherington, Dyke, 2010, interview by author, Fort Leavenworth, KS, October 25, 2010.

Doctrine

Headquarters, Department of the Army. 1994. Army Regulation (AR) 385–40, *Accident reporting and records.* Washington DC: Government Printing Office.

———. 2006a. Field Manual (FM) 3-04.15, *Multi-Service tactics, techniques, and procedures for the tactical employment of unmanned aircraft systems.* Washington DC: Government Printing Office.

———. 2006b. Army Regulation (AR) 95-23, *Unmanned aircraft systems flight regulations.* Washington DC: Government Printing Office.

———. 2006c. Training Circular (TC) 1-611, *Small unmanned aircraft system aircrew Training Manual.* Washington DC: Government Printing Office.

———. 2006d. Field Manual (FM) 3-21.10, *The infantry rifle company.* Washington DC: Government Printing Office.

———. 2006e. Field Manual (FM) 3-20.96, *Reconnaissance squadron.* Washington DC: Government Printing Office.

———. 2006f. Field Manual (FM) 3-90.6, *The Brigade Combat Team.* Washington DC: Government Printing Office.

———. 2006g. Training Circular (TC) 1-210, *Aircrew training program commander's guide to individual, crew, and collective training.* Washington DC: Government Printing Office.

———. 2007. Training Circular (TC) 1-600, *Unmanned aircraft systems commander's guide and aircrew training manual.* Washington DC: Government Printing Office.

———. 2009a. Field Manual (FM) 3-04.115, *Army unmanned aircraft systems operations.* Washington DC: Government Printing Office.

———. 2009b. Field Manual (FM) 6-02.53, *Tactical radio operations*. Washington DC: Government Printing Office.

———. 2009c. Field Manual (FM) 3-36, *Electronic warfare in operations.* Washington DC: Government Printing Office.

———. 2009d. Field Manual (FM) 3-20.971, *Reconnaissance and cavalry troop.* Washington DC: Government Printing Office.

———. 2009e. Army Regulation (AR) 95-23, *The Army safety program.* Washington DC: Government Printing Office.

US Joint Forces Command. 1993. Joint Publication (JP) 3-55.1, *Joint tactics, techniques, and procedures for unmanned aerial vehicles.* Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 3-52, 1995. *Doctrine for Joint airspace control in the combat zone.* Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 3-51, 2000. *Joint doctrine for electronic warfare.* Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 5-0, 2006. *Joint operation planning.* Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 3-13.1, 2007a. *Electronic warfare*. Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 3-50, 2007b. *Personnel recovery.* Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 3-0, 2008. *Joint operations.* Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 1-0, 2009a. *Doctrine for the armed forces of the United States.* Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 1-02, 2009b. *Department of Defense dictionary of military and associated terms.* Suffolk: Doctrine and Education Group.

———. Joint Publication (JP) 3-30, 2010. *Command and control for Joint air operations.* Suffolk: Doctrine and Education Group.

Other

Forest, Jason. Point of Contact for unpublished White Paper emailed to author titled: "BLUE KNIGHT Counter-Unmanned Aircraft System Test Support," undated. Received January 2011.